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## H 109—A Study in Variation.

By W. W. G. MOIR and E. L. CAUM.

*The most invariable thing in Nature is variation.*

Organic selection, or, as it is more commonly known, natural selection, is the selection carried on in plants and animals by Nature herself. It is based on the ability of the organism to adapt itself to its environment and to flourish in that environment, without regard to any other factor. All that is required is that it obey the Biblical injunction to "increase and multiply." If it cannot do that under the existing conditions it is eliminated, and its place is taken by one that can.

Contrasted with natural selection is what may be called, for want of a better term, artificial selection. Bud selection is artificial selection applied to plants. This type of selection consists in altering or adapting Nature's methods to human use.

No species of organisms is absolutely fixed. "Variations (V) occur, some of which are in the direction of increased adaptation (+); others in the direction of decreased adaptation (—). Acquired modifications (M) also occur. Some of these are in the direction of increased accommodation to circumstances (+), while others are in the direction of diminished accommodation (—). Four major combinations are:

(a) +V with +M

(c) —V with +M

(b) +V with —M

(d) —V with —M

Of these (d) must inevitably be eliminated while (a) are selected. The predominant survival of (a) entails the survival of the adaptive variations which are inherited. The contributory acquisitions (+M) are not inherited, but they are none the less factors in determining the survival of the coincident variations."



The preceding paragraph, which is quoted from "Darwin and Modern Science", chapter by C. L. Morgan, was written to apply to organic selection, but it is equally applicable to the other type. The four combinations are the same, the difference lying in the characteristics represented by the letters V and M. In organic selection they refer to factors which determine the actual existence of the organism, whereas in bud selection they refer to factors which determine the economic value of the plant.



An erect type of H 109 at the age of  $3\frac{1}{2}$  months.

All plants vary, and these variations are of three main types—those which are valuable, those which are of no particular significance, and those which are detrimental. The second class need not be considered. The principles of bud selection are to isolate and preserve the  $+V+M$  plants, to hold for observation the  $+V-M$  plants, and to eliminate the  $-V+M$  and  $-V-M$  plants.

In sugar cane we have a number of constitutional varieties which, to avoid confusion in terms, may be provisionally referred to as species. Taking, for example, H 109, and letting V refer to type of stooling and M to number of sticks per stool, we have the following combinations:



- +V+M = a deep-rooted stool with many sticks (4, 10, pp. 275, 279) ;  
 +V—M = a deep-rooted stool with few sticks (6, p. 279) ;  
 —V+M = a shallow-rooted stool with many sticks (1, p. 272) ; and  
 —V—M = a shallow-rooted stool with few sticks (2, p. 273).

Other characters might be used equally well. Erectness or recumbency of sticks is an inherited character as well as shallow or deep rooting, and size of sticks is dependent on environment, just as is number of sticks. We should preserve the deep-rooted, erect stools and discard the shallow-rooted, recumbent types, at the same time so modifying the conditions under which they must grow as to make the M's all + ; in other words, suit the agricultural practice to the cane so that each stool will produce a maximum number of large sticks rather than a few small ones.

In the October, 1921, number of the *Record* was published a progress report on the bud selection work carried on by this Station, in which it was stated that there existed in our standard canes various types or strains which could be isolated. Since that report was written there has been further study made of the strains of H 109, a discussion of which follows.

#### DEFINITION OF TERMS.

**Color:** The types are classed in three great color groups. This critical color is seen only on the upper part of the stick from which green leaves have just been removed. The color changes rapidly on exposure and ceases to be critical.

**Stooling:** (a) Bird's-nest. Shallow stooling, the sticks all arising very near the surface of the ground. The term "bird's-nest" is in itself rather a good description of this type.

(b) Standard. Deep stooling, the sticks arising well below the surface of the ground in a fairly compact group.

(c) Nondescript. A few scattered sticks, the stool type of which cannot be properly classified.

**Manner of Growth:** (a) Recumbent. The sticks of this type of stool all have a tendency to lie flat on the ground, this tendency making its appearance at a very early stage.

(b) Erect. In this type of stool the sticks all tend to stand upright and fairly close together.

(c) Semi-erect. This type is intermediate between the other two. The sticks do not stand upright, but neither do they lie along the ground. They tend to grow rather at an angle. In all these types the growth characters are best seen in young cane, because in older canes, where the sticks have attained considerable length, their weight is often sufficient to make the identification of types impossible.

**Shape of Sticks:** The shape, oval or round, as seen in cross-section.

**Miscellaneous:** Lala. The eyes on the upper part of the stick have a tendency to sprout when the cane is but one year old. These premature lalas prevent the normal elongation of the stick and, unless there is an excess of water available, they soon dry up, leaving the stick considerably stunted.

The types or strains of H 109 may be classified as follows:

- I. Green.
  - A. Bird's-nest
    - 1. Recumbent ( 1 )
  - B. Nondescript
    - 1. Recumbent ( 2 )
- II. White
  - A. Bird's-nest
    - 1. Semi-erect ( 3 )
      - a. Short-jointed
      - b. Lala
  - B. Standard
    - 1. Semi-erect ( 4 )
      - a. Oval sticks
      - b. Lala
    - 2. Erect ( 5 )
      - a. Normal
      - b. Lala
    - 3. Very erect ( 6 )
      - a. Short-jointed (turns red on exposure)
      - b. Long-jointed (turns purple on exposure)
      - c. Lala
- III. Orange
  - A. Bird's-nest
    - 1. Semi-erect ( 7 )
      - a. Normal
      - b. Lala
  - B. Nondescript
    - 1. Recumbent ( 8 )
  - C. Standard
    - 1. Semi-erect ( 9 )
      - a. Staggered-jointed normal
      - b. Lala
    - 2. Erect (10)
    - 3. Very erect (11)
      - a. Critical color light buff (rare)
      - b. Critical color dark buff

#### DISCUSSION OF TYPES.

(1) This type forms a stool of many extremely recumbent, medium-sized sticks. The short, sausage-shaped joints, which have a dried-out appearance, are at first olive green, soon turning lavender on exposure. With longer exposure the color changes to deep yellow, the shade of weather-beaten Lahaina cane. The sticks are of fair size at the base, but soon begin to taper out, many dying before reaching maturity. Due to the recumbent position of the sticks, many of the lower joints strike root, causing the eyes to sprout. This, besides lowering the



sucrose content of the stick, causes the production of a great number of weak shoots which soon die out. Although weak, this type is able to maintain itself to some extent for several crops, once it has become established. In the ratoons it produces many small, weak shoots which die under severe competition, so that frequently a field which seems to need no replanting when the ratoon shoots first appear has many gaps when the crop is harvested. For its full development this type needs an open position with plenty of sunlight and water, and where it is protected from the direct winds.

(2) This type, which is quite common, produces so few sticks per seed piece that they can hardly be dignified by the name "stool". The long, slender, soft, green joints turn to a light lemon yellow on exposure. Under direct sunlight



A recumbent type of H 109 at the age of  $3\frac{1}{2}$  months.

large red blotches appear on the internodes. With very favorable soil and water conditions canes of this type may develop good-sized sticks, but their softness makes them very susceptible to damage by drought and leaf-hopper, with a resulting lowering of the sucrose content. The recumbency is noted when the cane is but a few months old, for by that time the short sticks are lying prostrate. They are easily choked out by more erect types and are extremely subject to mechanical injury. In their efforts to push their leaves out into the sunlight the sticks become long and spindling, and many die under the severe competition which they must undergo. The eyes on these sticks are small, sunken and poorly developed. Many plantation men favor these small-eyed slender sticks as planting material because of the greater ease in handling and the greater area planted per bag of





The semi-erect white type of H 109, in a very favorable position.



seed. These advantages, however, are more than offset by the considerable amount of replanting that is necessary, and by the poor yield from the sticks that reach maturity. These slender, small-eyed canes are weak. They must have the best possible growing conditions if they are to survive, and among these conditions is an abundance of water—far more than is required by the heavier types.

Both these green types are extremely undesirable from an economic viewpoint, and pains should be taken to eliminate them from our fields.

(3) This white bird's-nest type, although undesirable, is superior to the green. Its many short-jointed sticks are so shallowly rooted that unless extra



H 109, 3½ months old. Note the difference between the erect type on the left and the recumbent type on the right.

care is given in the way of increased fertilization and irrigation, and unless the soil is pulled up around the stool, short, stunted sticks will be produced. A large patch of this type of cane is very noticeable in a field. A stool of this strain growing along a level-ditch or water-course will often appear excellent, but seed from it, planted under normal conditions, will give a mediocre crop. The lala-producing character is extremely common in this type, so by selecting against the prematurely-lalala stools it may be eliminated to a great extent.

(4) A stool of this type consists of a compact group of semi-erect, waxy-white, oval sticks, which on exposure turn first to a dark green and then to bluish purple. The sticks are very large in circumference and short-jointed in the lower part, the upper part producing joints of a good length. Although not





A recumbent type of H 109. Note the tendency to shallow rooting, the tapering sticks and spindling tops, in spite of the fact that the stool is growing in an especially favorable position.



as rapid a grower as the erect type, it is the first to "close in". It begins to stool out as soon as the primary shoot is a few inches high, and maintains this even stooling until the row is filled. It produces few sticks in comparison with the bird's-nest types, but what it does produce it carries through to maturity. Cane of this type should be excellent for late planting. A lala variety of this type exists, but fortunately is not common.

(5) This type is slightly more erect than the one described above. The sticks are round rather than oval, and are larger than the average. Stools of many stalks are occasionally found, but tonnage is obtained from the length



A semi-erect type of H 109 at the age of  $3\frac{1}{2}$  months.

and diameter of the sticks rather than from the number. This type, like all the other erect types, has a very heavy, waxy bloom, and leaves which are rather larger and more erect than ordinary and somewhat deciduous, as are the sheath hairs. In these respects this type contrasts strongly with those described above. Canes of this type stool out much more slowly than do those of type (4), but the late shoots are such strong and rapid growers that they soon find their "place in the sun". As a ratooning cane this type is excellent. It produces, not a great number of small shoots, most of which soon die, but a few well-placed sturdy ones which pull through to maturity.





A stool of the long-jointed very erect white type of H 109, under exceptionally good growing conditions.



(6) The very erect white types are of two kinds, one long-jointed and vigorous, the other short-jointed and less vigorous. A lala variety has been found, but the few examples noted have all belonged to the second kind, which is a poor stooling cane with rather short, straight sticks made up of short joints telescoped together. Under ideal conditions the first year's growth is rapid. The growth during the second year is much slower, resulting in many short, stubby joints. When the leaves are stripped from the upper part of the stick the white color turns after a few hours' exposure to a deep red and later to a deep reddish purple. This variety of erect white is unproductive, and should be eliminated.

The long-jointed erect white type is very uncommon, only one good example having been seen. The joints are long, fairly straight, and covered with a peculiar network of fine lines. The sticks on exposure remain very light purple. The eye is fairly large and set close to the stick. In a district where high winds prevail this type would be undesirable, as it is very brittle and easily broken off at the base. In stooling and ratooning properties it is very similar to type (5).

(7) The only differences between this type and type (3) are in the color, which is a decided orange instead of white, and in the longer joints. It seems to be very adaptable to conditions as it finds them, but in spite of this it is sufficiently undesirable to warrant elimination.

(8) An orange type very similar to the green described as type (2) is often found on Oahu. The long, very slender stick is not attractive in appearance. The stools are small, recumbent, and easily shaded out. On exposure these canes turn to dark bronze purple. This type seldom produces a large stick, so that elimination in the field is easily accomplished by discarding all small-stalked stools.

(9) This orange type closely resembles the white type (4), except that the sticks are round in cross-section rather than oval, and that the joints are longer and slightly smaller in diameter. As the sticks increase in length they tend to become recumbent. Stools of this type never consist of very many sticks, but the individual sticks are frequently of great length, often 25 or 30 feet. This type is neither exceptionally good nor exceptionally poor, but should be preserved for further study.

(10) This is an excellent type, differing from type (5) only in the critical color. In some localities this type seems to predominate, and from the juice figures obtained from those fields it would appear to be one of the most valuable strains of the variety. Incidentally, this strain is the one most frequently chosen as "typical H 109".

(11) This very erect type is so decidedly orange in color and has so little bloom that it is easily identified. Some variations in intensity of color exist, but they are of minor importance. The sticks are never very large or very long, and the staggered joints are of uniform diameter. Under exposure the orange color changes to deep bronze, overlaid with purple. On a "tonnage per acre" basis this type is mediocre, and should be replaced by better ones.

Slight variations exist in many of the above types—gradations from one type to the next within the color group, variations in shape and size of the eye, and other minor differences. Since many of these are obviously due to the environ-





A mixed stool of H 109. The five sticks at the left are of the erect orange type, while the five at the right are semi-erect white.



ment, however, and others are correlated with more decided type characteristics, they will not be discussed at this time.

In addition to these strains, there are several distinct mutations or sports known. These are striped canes, which to all outward appearances differ from the basic types from which they originated only in the fact that the sticks are striped instead of self-colored. They may differ in other ways, but lack of data due to their rarity precludes their discussion.

It should be noted here that the data on which these notes are based were obtained on Maui. It is altogether probable, however, that the types of Oahu, Hawaii and Kauai will be comparable to those of Maui, if not identical with them.

#### CONCLUSION.

The constitutional cane variety known as H 109 is composed of many distinct strains or types, some of which are of great value economically, while others are decidedly inferior and detrimental to our tonnage yields.

The most desirable strains, and the ones which should be spread as rapidly as possible, are those described as types (4), (5), (9) and (10). A general and speedy elimination of the following classes would materially improve the quality of our H 109 fields:

1. All green types.
2. All bird's-nest and nondescript stool types.
3. All very recumbent and very erect types.
4. All lala types.

With these nonproductive types eliminated, the plantations of Hawaii would be well on their way toward getting the maximum yield from this standard variety. Mass plantings of the four types named as desirable would furnish valuable material for progeny test plantings. In connection with this it should be remembered that the fact that a selected stool of cane happens to be predominantly one of the desirable types does not necessarily mean that selection should stop there. All the stools of a given type group are not of the same quality, and progeny test plantings are necessary if the maximum-yielding strains of this group are to be isolated and brought up to plantation acreage.

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## Experiments at Pioneer Mill.

### PIONEER MILL CO. EXPERIMENTS 1, 2, 3, 4, AND 5, 1921 CROP.

During August, 1921, we harvested five experiments at Pioneer Mill Company. These were located in the Kaanapali Section in Field B-6, at an elevation of about 420 feet. The cane was plant, planted in July, 1919. Except in Experiment No. 1, which was a variety test, the cane was Striped Mexican.

The experiments were irrigated about every 30 days from August, 1919, to November, 1920, and had one irrigation in May, 1921. During this time this field got 28 inches of rain. At the time of harvest the cane was rather dry.



## PIONEER MILL CO. EXPERIMENT NO. 1, 1921 CROP.

## VARIETY TEST.

This was a variety test with plant cane in which D 1135, H 109, Striped Mexican, H 33, Lahaina, and H 146 were compared.

The results obtained at harvest are given in the following tabulation:

No. of Plots	Variety	Yield per Acre		
		Cane	Q. R.	Sugar
10	D 1135 .....	51.5	6.93	7.44
10	H 109 .....	44.6	6.75	6.60
10	Lahaina .....	41.4	6.70	6.17
10	Striped Mexican .....	44.2	7.18	6.16
10	H 33 .....	43.4	7.69	5.64
10	H 146 .....	30.2	7.49	4.03

Under the conditons of this experiment where a shortage of water existed, D 1135 proved the better cane, followed by H 109. The other varieties were distinctly inferior; H 146, especially, was a failure. During the last two or three years this variety has been doing very poorly and should not be planted on any extensive areas. It is a poor ratooner and is susceptible to Lahaina disease.

It is interesting to note that in this experiment the D 1135 juices were practically as good as were those of the H 109 or Lahaina. We believe that, in the majority of cases, where very poor juices are reported from D 1135 cane, that they are due to the presence of immature suckers. The age of suckers when harvested has a very important bearing on the yields obtained from D 1135.

## DETAILS OF EXPERIMENT.

**Object:**

To compare H 33, H 109, H 146, D 1135, Striped Mexican, and Lahaina.

**Location:**

Pioneer Mill Co., Field B-6, Kaanapali Section.

**Layout:**

Number of plots=60.

Size of plots=1/20 acre, consisting of 7 rows two watercourses long; by measurement, 31.5' x 69.15' from center to center of watercourses.

Each row=4.5' x 69.15'.

**Crop:**

H 33, H 109, H 146, D 1135, Striped Mexican, and Lahaina; plant crop.

**Plan:**

Fertilization—Two doses of high grade and two doses of nitrate of soda, amounting to 200 pounds of nitrogen and 120 pounds of  $P_2O_5$ , per acre, uniform or regular plantation practice.

Experiment planned by J. A. Verret and L. T. Lyman.

Experiment laid out by L. T. Lyman.



EXP. 1. VARIETY TEST.

EXP. 2. AMOUNT OF NITROGEN TO APPLY.

EXP. 3. PHOSPHORIC ACID REQUIREMENTS.

EXP. 4. PLANT FOOD REQUIREMENTS.

EXP. 5. NUMBER OF APPLICATIONS.

Pioneer Mill Co. Expts. 1, 2, 3, 4 &amp; 5, 1921 Crop

		Level								Ditch							
EXP. 1.	Str.Mex.	H109	Lah.	H146	D1135	H33	Lah	H109		Str.Mex.	H109	Lah.	H146	D1135	H33	Lah	H109
	H146	Str.Mex.	H109	Lah.	H33	D1135	H33	Str.Mex.		H146	Str.Mex.	H109	Lah.	H33	D1135	H33	Str.Mex.
	D1135	H146	Str.Mex.	H109	Lah.	H146	D1135	H33		D1135	H146	Str.Mex.	H109	Lah.	H33	D1135	H33
	H33	D1135	H146	Str.Mex.	H109	Lah.	H146	D1135		H33	D1135	H146	Str.Mex.	H109	Lah.	H33	D1135
	Str.Mex.	H33	D1135	H33	Str.Mex.	H109	Lah.	H146		H109	Str.Mex.	H33	D1135	H33	Str.Mex.	H109	Lah.
	H109	Lah.	H33	D1135	H146	Str.Mex.	H109	Lah.		H109	Lah.	H33	D1135	H146	Str.Mex.	H109	Lah.
EXP. 2.	Str.Mex.	H33	1 X 51.10	2 A 50.90	3 B 49.10	4 C 54.20	5 D 52.40	6 X 40.35		Str.Mex.	H33	1 X 51.10	2 A 50.90	3 B 49.10	4 C 54.20	5 D 52.40	6 X 40.35
	H109	D1135	7 D 51.40	8 X 37.80	9 A 41.30	10 B 52.20	11 C 51.70	12 D Discarded		H109	D1135	7 D 51.40	8 X 37.80	9 A 41.30	10 B 52.20	11 C 51.70	12 D Discarded
	Lah.	H146	13 C 51.30	14 D 57.45	15 X 35.65	16 A 41.60	17 B 44.40	18 C 43.95		Lah.	H146	13 C 51.30	14 D 57.45	15 X 35.65	16 A 41.60	17 B 44.40	18 C 43.95
	H146	Lah.	19 B 47.00	20 C 44.30	21 D 50.70	22 X 42.00	23 A 48.40	24 B 48.85		H146	Lah.	19 B 47.00	20 C 44.30	21 D 50.70	22 X 42.00	23 A 48.40	24 B 48.85
	D1135	H109	25 A 44.35	26 B 56.60	27 C 50.90	28 D 53.60	29 X 34.50	30 A 43.20		D1135	H109	25 A 44.35	26 B 56.60	27 C 50.90	28 D 53.60	29 X 34.50	30 A 43.20
	H33	Str.Mex.	31 X 45.20	32 A 40.20	33 B 45.75	34 C 55.00	35 D 51.40	36 C 59.75		H33	Str.Mex.	31 X 45.20	32 A 40.20	33 B 45.75	34 C 55.00	35 D 51.40	36 C 59.75
EXP. 2.	37 B 50.45	38 C 47.15	39 D 60.80	40 X 43.80	41 A 43.80	42 B 48.40	43 C 48.95	44 D 53.60		37 B 50.45	38 C 47.15	39 D 60.80	40 X 43.80	41 A 43.80	42 B 48.40	43 C 48.95	44 D 53.60
	45 A 37.60	46 B 43.80	47 C 42.75	48 D 53.35	49 X 33.15	50 A 44.35	51 B 50.70	52 C 46.25		45 A 37.60	46 B 43.80	47 C 42.75	48 D 53.35	49 X 33.15	50 A 44.35	51 B 50.70	52 C 46.25
	53 X 34.00	54 A 40.90	55 B 53.00	56 C 47.75	57 D 54.65	58 X 44.00	59 A 46.40	60 B 53.25		53 X 34.00	54 A 40.90	55 B 53.00	56 C 47.75	57 D 54.65	58 X 44.00	59 A 46.40	60 B 53.25
	61 D 40.00	62 X 41.80	63 A 33.85	64 B 45.60	65 C 46.45	66 D 47.50	67 X 52.05	68 A 40.00		61 D 40.00	62 X 41.80	63 A 33.85	64 B 45.60	65 C 46.45	66 D 47.50	67 X 52.05	68 A 40.00
	69 D 38.10	70 X 41.40	71 A 42.65	72 B 38.00	73 C 43.00	74 D 42.80	75 X 38.90	76 A 45.00		69 D 38.10	70 X 41.40	71 A 42.65	72 B 38.00	73 C 43.00	74 D 42.80	75 X 38.90	76 A 45.00
	77 X 45.40	78 A 50.50	79 B 40.80	80 C 47.30	81 D 54.10	82 X 45.10	83 A 43.45	84 B 45.45		77 X 45.40	78 A 50.50	79 B 40.80	80 C 47.30	81 D 54.10	82 X 45.10	83 A 43.45	84 B 45.45
EXP. 3.	85 G 46.00	86 E 43.45	87 F 42.95	88 G 46.45	89 C 45.90	90 F 42.95	91 E 46.45	92 G 46.30		85 G 46.00	86 E 43.45	87 F 42.95	88 G 46.45	89 C 45.90	90 F 42.95	91 E 46.45	92 G 46.30
	93 F 42.95	94 G 46.45	95 C 45.90	96 F 42.95	97 E 46.45	98 G 46.30	99 C 45.90	100 F 42.95		93 F 42.95	94 G 46.45	95 C 45.90	96 F 42.95	97 E 46.45	98 G 46.30	99 C 45.90	100 F 42.95
	101 E 45.90	102 F 46.45	103 G 46.30	104 C 45.90	105 F 42.95	106 E 46.45	107 G 46.30	108 C 45.90		101 E 45.90	102 F 46.45	103 G 46.30	104 C 45.90	105 F 42.95	106 E 46.45	107 G 46.30	108 C 45.90
	109 F 42.95	110 G 46.45	111 C 45.90	112 F 42.95	113 E 46.45	114 G 46.30	115 C 45.90	116 F 42.95		109 F 42.95	110 G 46.45	111 C 45.90	112 F 42.95	113 E 46.45	114 G 46.30	115 C 45.90	116 F 42.95
	117 E 45.90	118 F 46.45	119 G 46.30	120 C 45.90	121 F 42.95	122 E 46.45	123 G 46.30	124 C 45.90		117 E 45.90	118 F 46.45	119 G 46.30	120 C 45.90	121 F 42.95	122 E 46.45	123 G 46.30	124 C 45.90
	125 F 42.95	126 G 46.45	127 C 45.90	128 F 42.95	129 E 46.45	130 G 46.30	131 C 45.90	132 F 42.95		125 F 42.95	126 G 46.45	127 C 45.90	128 F 42.95	129 E 46.45	130 G 46.30	131 C 45.90	132 F 42.95
EXP. 4.	128 C 42.15	129 H 43.35	130 I 50.30	131 J 46.85	132 C 47.75	133 H 52.60	134 I 61.80	135 J 46.15		128 C 42.15	129 H 43.35	130 I 50.30	131 J 46.85	132 C 47.75	133 H 52.60	134 I 61.80	135 J 46.15
	137 J 46.60	138 C 47.25	139 H 47.35	140 I 41.60	141 J 43.45	142 C 51.50	143 H 43.05	144 I 51.40		137 J 46.60	138 C 47.25	139 H 47.35	140 I 41.60	141 J 43.45	142 C 51.50	143 H 43.05	144 I 51.40
	146 I 45.10	147 J 45.40	148 C 46.00	149 H 42.60	150 I 51.15	151 J 48.40	152 C 59.90	153 H 55.80		146 I 45.10	147 J 45.40	148 C 46.00	149 H 42.60	150 I 51.15	151 J 48.40	152 C 59.90	153 H 55.80
	155 H 39.10	156 I 44.30	157 J 48.60	158 C 42.65	159 H 42.20	160 I 52.80	161 J 72.80	162 C 45.30		155 H 39.10	156 I 44.30	157 J 48.60	158 C 42.65	159 H 42.20	160 I 52.80	161 J 72.80	162 C 45.30
	165 H 44.30	166 I 44.15	167 J 43.60	168 C 43.60	169 H 42.70	170 I 48.95	171 J 46.70	172 C 53.15		165 H 44.30	166 I 44.15	167 J 43.60	168 C 43.60	169 H 42.70	170 I 48.95	171 J 46.70	172 C 53.15
	173 H 52.30	174 I 48.30	175 J 50.45	176 C 55.75	177 H 50.45	178 I Discarded	179 J 46.00	180 C 53.70		173 H 52.30	174 I 48.30	175 J 50.45	176 C 55.75	177 H 50.45	178 I Discarded	179 J 46.00	180 C 53.70
EXP. 5.	181 L 51.95	182 C 48.05	183 K 48.70	184 L 49.70	185 C 47.95	186 K Discarded	187 L 63.00	188 C 51.75		181 L 51.95	182 C 48.05	183 K 48.70	184 L 49.70	185 C 47.95	186 K Discarded	187 L 63.00	188 C 51.75
	190 K 47.15	191 L 46.05	192 C 46.70	193 K 48.40	194 L 49.25	195 C Discarded	196 K 52.55	197 L 44.40		190 K 47.15	191 L 46.05	192 C 46.70	193 K 48.40	194 L 49.25	195 C Discarded	196 K 52.55	197 L 44.40
	198 C 50.90	199 K 48.60	200 L 51.55	201 C 48.60	202 K 47.00	203 L 52.75	c.c.	c.c.		198 C 50.90	199 K 48.60	200 L 51.55	201 C 48.60	202 K 47.00	203 L 52.75	c.c.	c.c.
	204 L 45.85	205 C 45.25	206 K 52.90							204 L 45.85	205 C 45.25	206 K 52.90					

Note - 12 plots on left of upper  
Exp. 2. = Exp. 1. Others = Exp. 2.



## PIONEER MILL CO. EXPERIMENT NO. 2, 1921 CROP.

## AMOUNT OF FERTILIZER TO APPLY.

This was a test to determine the economic limit in fertilization under conditions of a certain amount of water shortage.

During the first year a mixed fertilizer was used. This fertilizer contained 10% nitrogen, 7% phosphoric acid, and 3.75% of potash. Nitrate of soda was used during the second growing season.

The amounts of fertilizer used and the yields obtained are tabulated as follows:

Pounds per Acre		Pounds of Nitrogen	Yield per Acre		
Mixed Fert.	Nit. of Soda		Cane	Q. R.	Sugar
0	0	0	42.2	6.49	6.50
500	322	100	43.5	6.61	6.58
750	484	150	48.4	6.55	7.39
1000	645	200	49.2	6.82	7.22
1250	806	250	49.4	6.76	7.30

The results obtained from the fertilizer here were not specially striking and did not extend above 150 pounds of nitrogen per acre, obtained from 750 pounds of high grade the first year, and 484 pounds of nitrate of soda the second year.

## DETAILS OF EXPERIMENT.

**Object:**

To determine the economic limit of nitrogen as a fertilizer on the lands of Pioneer Mill Co. that have been cropped for many years.

**Location:**

Pioneer Mill Co., Field B-6.

**Crop:**

Striped Mexican, plant.

**Layout:**

No. of plots = 81.

Size of plots = 1/20 acre; each plot is 7 lines by 2 watercourses, each line being 4.5' wide by 69.15' long.

**Plan:**

## POUNDS NITROGEN PER ACRE.

Plots	No. of Plots	Sept. 1, 1919	Nov. 1, 1919	Feb. 15, 1919	Apr. 15, 1919	Total Nitrogen
X	16	0	0	0	0	0
A	16	25	25	25	25	100
B	16	37.5	37.5	37.5	37.5	150
C	16	50	50	50	50	200
D	17	62.5	62.5	62.5	62.5	250



Mixed fertilizer first season—10% N. ( $3\frac{1}{2}$  N. S., 5 Sulf. Amm.,  $1\frac{1}{2}$  Org.), 7%  $P_2O_5$  (Super.), 3.75%  $K_2O$ .

Nitrate of soda second season—15.5% N.

Experiment planned by J. A. Verret and L. T. Lyman.

Experiment laid out by L. T. Lyman.

## PIONEER MILL COMPANY EXPERIMENT NO. 3, 1921 CROP.

### PHOSPHORIC ACID TEST.

In this experiment varying amounts of phosphoric acid were tried. The results obtained are tabulated below:

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
No phosphate .....	44.8	7.18	6.24
60 lbs. phosphoric acid ( $P_2O_5$ )....	44.4	7.35	6.04
100 lbs. phosphoric acid ( $P_2O_5$ )....	45.3	7.24	6.26
140 lbs. phosphoric acid ( $P_2O_5$ )....	46.3	7.22	6.41
Average of all $P_2O_5$ plots .....	45.3	...	6.24

There is apparently some response to phosphates in this test, but the response is slight and somewhat contradictory. The average yield of sugar from the no-phosphate plots was the same as that from the plots which had phosphate. This may be due to some experimental error, as indicated by the gradual increase in yields as the amounts of  $P_2O_5$  used were increased from 60 to 140 pounds per acre. This increase amounts to about 0.2 ton of sugar for each 60 pounds of  $P_2O_5$ .

On account of the slight differences between the various treatments it is considered best to await the results from the next ratoon crop before arriving at any definite conclusion.

### DETAILS OF EXPERIMENT.

**Object:**

To determine the profitable limit in the application of phosphoric acid.

**Location:**

Pioneer Mill Co., Field B-6, Kaanapali Section.

**Crop:**

Striped Mexican, plant.

**Layout:**

46 plots, each  $\frac{1}{20}$  acre, 7 lines 2 watercourses long. Each line 4.5' by 69.15' from center to center of watercourse.



Plan:

## FERTILIZATION\* — POUNDS PER ACRE.

Plots	No. of Plots	Nitro- gen, Sept., 1919	Phos. Acid, Sept., 1919	Nitrogen			Total Pounds	
				Nov., 1919	Feb., 1919	Apr., 1919	N.	P <sub>2</sub> O <sub>5</sub>
C	11	50	0	50	50	50	200	0
E	12	50	60	50	50	50	200	60
F	12	50	100	50	50	50	200	100
G	11	50	140	50	50	50	200	140

\* P<sub>2</sub>O<sub>5</sub> from superphosphate = 16% P<sub>2</sub>O<sub>5</sub>.

Nitrogen from nitrate and sulphate mixture = 17½% N.

## PIONEER MILL CO. EXPERIMENT NO. 4, 1921 CROP.

## PHOSPHORIC ACID AND POTASH TEST.

This was a test to determine the needs for phosphoric acid and potash of the soils in the Kaanapali section of this plantation.

In this experiment slight gains were obtained from both potash and phosphoric acid. The gain from potash alone amounted to about one ton of cane per acre. A gain of this nature is too small to be accepted as definite.

The plots getting both phosphoric acid and potash show larger gains, amounting to about 0.3 ton of sugar per acre.

The yields obtained in Experiment No. 4 were as follows:

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Nitrogen only .....	48.4	6.73	7.19
Nitrogen and Potash (100 lbs. K <sub>2</sub> O) ..	48.9	6.69	7.31
Nitrogen and Potash (200 lbs. K <sub>2</sub> O) ..	49.4	6.71	7.36
Nitrogen, Phos. Acid and Potash .....	50.8	6.71	7.57

## DETAILS OF EXPERIMENT.

## Object:

To determine the plant food requirements of sugar cane under conditions at Pioneer Mill Co.

## Location:

Pioneer Mill Co., Field B-6.

## Crop:

Striped Mexican, plant.

## Layout:

No. of plots = 66.

Size of plots = 1/20 acre, consisting of 6 lines, each line being 5' wide by 72.6' long.

**Plan:**

Plots	No. of Plots	Sept. 1, 1919			Nov. 1, 1919	Feb. 15, 1920	Apr. 15, 1920	Total Pounds per Acre		
		N.	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	N.	N.	N.	N.	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
C	13	50	...	...	50	50	50	200	...	...
H	13	50	100	100	50	50	50	200	100	100
I	13	50	...	100	50	50	50	200	...	100
J	13	50	...	200	50	50	50	200	...	200

N. = 17½% mixture = ½ nitrate soda = ½ amm. sulph.

P<sub>2</sub>O<sub>5</sub> = acid phosphate 16%.

K<sub>2</sub>O = sulph. potash 50%.

Experiment planned by J. A. Verret and L. T. Lyman.

Experiment laid out by L. T. Lyman.

### PIONEER MILL CO. EXPERIMENT NO. 5, 1921 CROP.

#### FERTILIZER — HOW TO APPLY.

In this experiment we tried applying a given amount of fertilizer in two, three and four doses. A total of 200 pounds of nitrogen per acre was used. Half of this nitrogen was from a mixed fertilizer containing 10% nitrogen, 7% phosphoric acid, and 3.75% potash. The other half, applied during the second season, was from nitrate of soda.

The yields obtained from the different treatments were identical, as shown below:

No. of Applications	Yields per Acre		
	Cane	Q. R.	Sugar
Two applications .....	49.2	7.16	6.88
Three " .....	48.9	7.16	6.84
Four " .....	49.1	7.16	6.86

The results obtained from this experiment confirm those obtained from our other experiments on this subject. There is nothing to gain by applying fertilizer in more than two or three doses per two-year crop.

#### DETAILS OF EXPERIMENT.

**Object:**

To determine the most profitable number of applications in which a given amount of fertilizer should be applied.

**Location:**

Pioneer Mill Co., Field B-6.

**Crop:**

Striped Mexican, plant.



**Layout:**

No. of plots = 27.

Size of plots =  $1/20$  acre; each plot is 7 lines by 2 watercourses, each line being 4.5' wide, 69.15' long. One guard row along level ditch.

**Plan:**

## POUNDS OF NITROGEN PER ACRE.

Plots	No. of Plots	Sept., 1919	Nov., 1919	Feb., 1920	Apr. 1, 1920	Total Nitrogen per Acre
C	9	50	50	50	50	200
K	9	100	0	100	0	200
L	9	50	50	100	0	200

First season, mixed fertilizer = 10% N. ( $3\frac{1}{2}$  N. S., 5 Sul.,  $1\frac{1}{2}$  Org.), 7%  $P_2O_5$  (Super.), 3.75%  $K_2O$ .

Second season nitrate of soda = 15.5% N.

Experiment planned by J. A. Verret.

Experiment laid out by L. T. Lyman.

J. A. V.

## Artificial Farmyard Manure.\*

An article in the August issue of the Journal of the Ministry of Agriculture under the above title somewhat modestly announces what must be regarded as one of the most notable advances in agricultural science made by our oldest agricultural research laboratory, the Rothamsted Experimental Station. For many years the composition and fertilizing value of farmyard manure have occupied the attention of investigators. The chemical problems involved at first sight appear simple. When cattle are fed with food rich in nitrogen there is a corresponding enrichment of their excrement. "Cake-fed" dung has long been given a high value by the farmer, and on a purely chemical basis its merit was recognized by the man of science. Hence such publications as "Hall and Voelcker's Tables," which give the "residual" values of various foodstuffs—that is to say, the value of the fertilizing constituents (mainly nitrogen) in various substances present in the dung of animals to which they have been fed. But the perplexing fact emerged that dung with this higher theoretic value did not give crop increases corresponding to its assumed chemical content. Nevertheless, so strong has been the effect of the publication of these theoretic values that they are given quasi-statutory effect. Entering tenants have generally to pay compensation "for improvements" based upon the quantity and quality of the foods consumed on the farm during the years preceding their entry.

In the paper alluded to, Messrs. Hutchinson and Richards indicate the solu-

\* From Nature, August 25, 1921.

tion of the conundrum. Put shortly, they have established that the whole of nitrogen in the urine of animals will not be present in the manure as applied to the crops unless a certain ratio subsists between the nitrogen voided by the animals and the carbonaceous matter of the litter by which the urine is absorbed. It seems to follow that "compensation for improvements" should not be awarded on the basis of the food supplied to the stock until the valuer is assured that the feeding was accompanied by an adequate supply of litter, the adequacy being determined by the amount of nitrogen voided by the animals.

Messrs. Hutchinson and Richards show that the factors involved are, in the main, biological, not chemical. The "making" of farmyard manure is essentially the rotting or fermentation of straw. The former writer has published a paper (*Journal of Agricultural Science*, 1919, p. 143) which establishes that straw is fermented by a new aerobic organism, *Spirochaeta cytophaga*, and that this organism requires (in addition to air) a supply of nitrogen, preferably in the form of an ammonia compound (such as, in effect, urea is). It is shown that the amount of nitrogen required for the fermentation of 100 pounds of straw is 0.72 pound. Further, if the nitrogen is in excess of this amount, it tends to pass into the atmosphere as ammonia, with the result that, with a free supply of air, the end product is dung containing about 2 per cent of nitrogen, whatever the original content of the excrement may have been. Under the conditions, however, which obtain in the ordinary farmyard, where some portions of the heap may receive more excrementitious matter than others, the ammonia set free where the nitrogen : cellulose proportion is greater than 0.72 : 100 may be picked up by those portions where the ratio is less, and used to build up their nitrogen content until the whole heap reaches the characteristic and uniform 2 per cent content of nitrogen.

Using these results, it has been found possible to make an artificial product, closely resembling farmyard manure in appearance as well as in properties, by the addition of predetermined amounts of ammonia salts (such as ammonium sulphate) to straw. The commercial value of this development may be considerable. With the advent of the motor the supply of town dung has fallen off. Many market-gardeners are, consequently, in straits, for the so-called artificial manures are lacking in organic matter (humus), without which many garden and glasshouse crops cannot be grown satisfactorily. It may be that the ordinary farmer, too, will find a use for the artificial product. It is difficult under modern conditions to maintain sufficient animals to make all the straw produced into dung. Again, where animal excrements exist in abundance (as in milk production), lack of knowledge of the principles of the interaction between urine and straw leads to much waste of valuable fertilizing material.

Another direction in which these discoveries may have a practical outcome is in removing the soluble compounds of nitrogen present in sewage. Under the existing sludge processes very little of this soluble matter is recovered. It has been shown that if liquid sewage is used to ferment straw, the effluent is practically free from nitrogen; it has all been retained by the straw.

Enough has, perhaps, been said to indicate the great practical importance of the discovery made by the Rothamsted workers. The scientific advance is not less notable, and marks another stage in the capture by the biologists of the agricultural field of research.



## Corrosion of Boiler Supporting Columns.\*

### SULPHUR IN ASH AND SOOT EATS AWAY MAIN COLUMNS SUPPORTING BOILERS.

A vital enemy of iron or steel is sulphuric acid. If the sulphur in the coal could be eliminated it would save us quite a few of our boiler troubles. Engineers are aware of this undesirable element getting into the tubes or drums of their boilers, and much attention is given to eliminating it from their feed water by use of the various compounds and water treatment devices. Engineers also realize that when it comes to the time for them to clean and prepare their boilers for an internal inspection, the brickwork must be removed from around the blowdown pipe; if the engineer in charge does not issue these orders to the one cleaning the boiler, the inspector will remove them himself.

The inspector realizes the great danger in allowing the soot and ash to bank around boiler blowdown pipes. This soot contains a large amount of sulphur, and when it becomes damp or wet soaks through the brickwork, whereby the sulphur and the oxygen in the water set up a chemical action. This chemical action causes pitting or corrosion which will in time eat through the metal if allowed to remain, and when the boiler is blown down may crack or explode, thereby blowing the fire into the fire-room, possibly injuring several persons. Such accidents are frequent. Lists of accidents are published periodically by insurance companies or by the department of labor at Washington. Boiler blow-

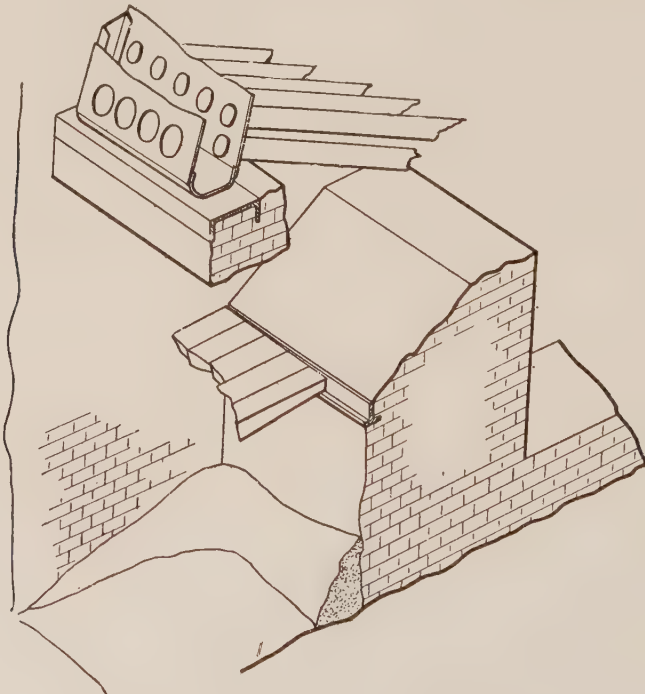


Fig. 1. Typical ashpit of water-tube boiler.

\* From Power Plant Engineering.

pipes usually must be replaced about every five years, and accidents resulting from them usually cause considerable delay and expense.

How many engineers ever examine the foundations of their boilers or the columns which support the entire mass of weight? The owner would certainly object if you were to tell him that it would be necessary to remove a part of the brickwork at the base of the sidewalls of his boilers, especially where the boilers are in batteries.

Here is a vital consideration that should be called to the attention of all boiler inspectors and engineers, and it is something that we cannot lay too much stress upon. In visits to power plants, trouble resulting from corrosion at the foundation of main boiler supporting columns is frequently found. On one visit it was found that these columns that had been supporting a 1000-horsepower water-tube boiler had become so corroded at the base that it was amazing how it had stood. The brickwork or sidewalls evidently had been supporting the boiler against collapsing. After this discovery, the brickwork was removed from around all of the boilers in three large power plants operated by the company and five similar boilers were found in like condition, which had to be replaced at great expense and inconvenience.

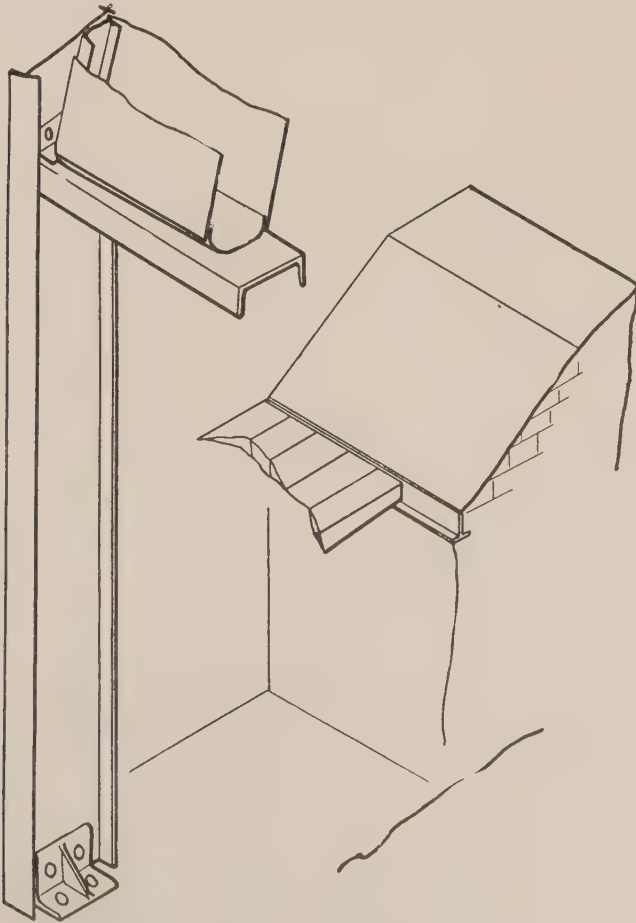


Fig. 2. Ashpit with brickwork removed.



Upon examination of these columns it was found that the ash and soot that had piled up along the sidewalls, and the water resulting from the quenching of the hot coals had penetrated the brickwork, and the sulphur in the refuse with the oxygen in the water quickly consumed the steel, causing this serious damage.

Figure 1 shows a typical ashpit of a water-tube boiler with the steel column hidden. Engineers seldom if ever stop to think that anything would ever happen

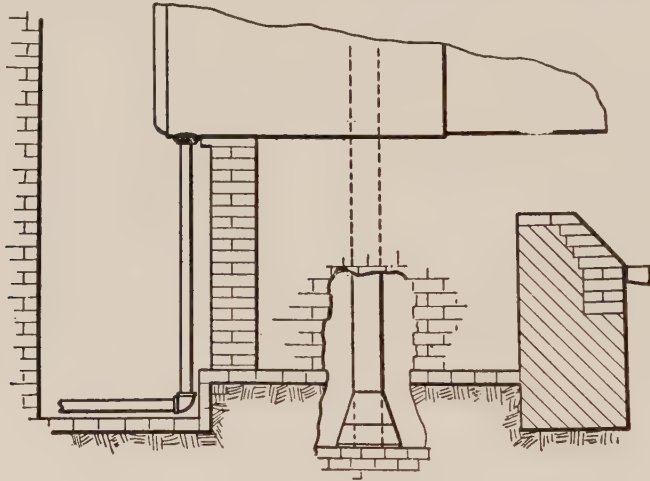


Fig. 3. Location of columns supporting return tubular boiler.

to them, as, to the eye, they look pretty well protected. But engineers must realize that this protection is only a porous fireproof brick which will absorb moisture readily. This moisture must pass through the ash or soot.

Coal from some mines will run about  $4\frac{1}{2}\%$  sulphur, and when referred to sulphur in the ash this figure is considerably higher. So it may be well under-

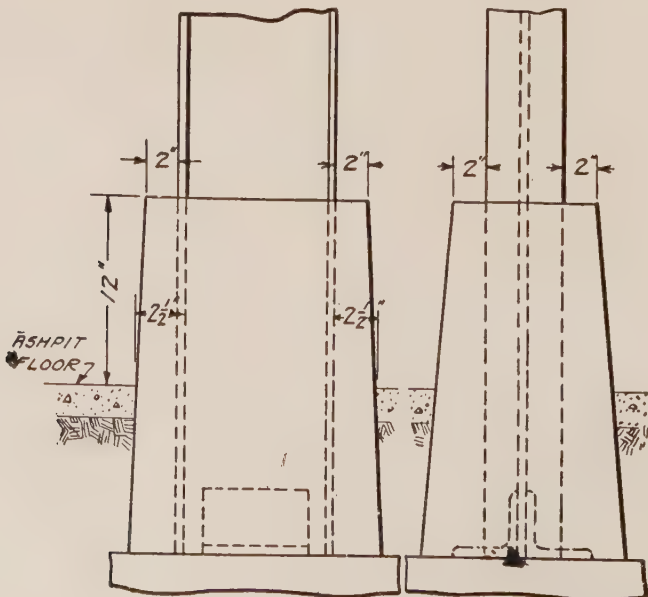


Fig. 4. Concrete casing to protect base of column.

stood that this moisture passing through the ash will absorb much of this sulphur, and if allowed to remain on the steel will cause rapid corrosion.

Figure 2 shows the same ashpit of a water-tube boiler with the brickwork removed. In this view, see how the main columns are located at the side of the ashpit. In Figure 3 is shown how the column is located on a horizontal return tubular boiler with the brickwork removed from around the base. This brickwork should be removed for a periodic examination.

This corrosion can be prevented by building a foundation of a good cement around the base which will extend about one foot above the ashpit floor, the proportions for which are shown in Figure 4.

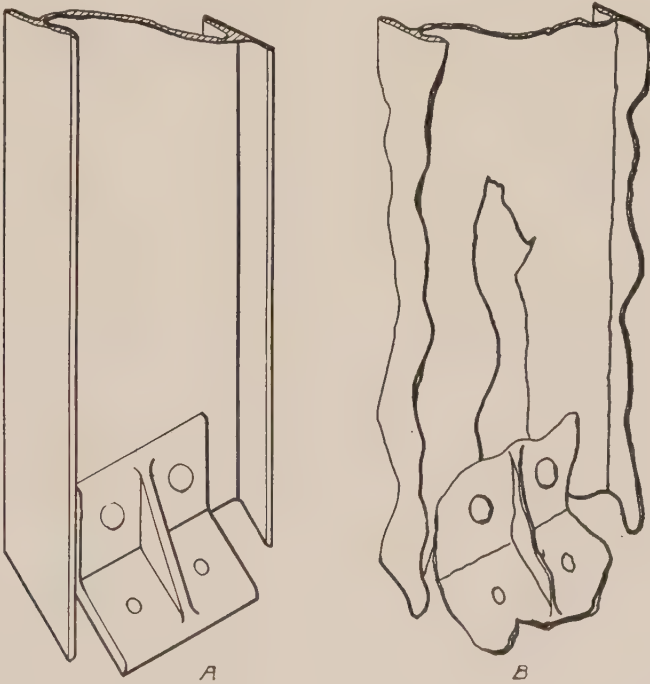


Fig. 5. Foot of column before and after corrosion.

In Figure 5A is shown an enlarged view of the columns that had to be replaced in the aforesaid plant, and 5B shows how they had been corroded away when discovered; the metal had been so eaten away that there was practically no support whatsoever. If engineers would examine their boiler foundations, not less than 25 per cent would find just such conditions.

Cleaning up a boiler-room is a man's job. Keeping it clean is a bigger man's job. Increasing its efficiency is a still bigger man's job—and this leads directly to a still bigger job. Why not start?

[W. E. S.]



## The Effect of Some Decolorizing Carbons Upon the Color and Colloids of Cane Juice.\*

By JOSEPH F. BREWSTER and WILLIAM G. RAINES, JR.

*This paper was presented before the Section of Sugar Chemistry and Technology at the 61st meeting of the American Chemical Society, Rochester, N. Y., April 26 to 29, 1921.*

*The matter described in this paper is the result of cooperation between the Bureau of Chemistry, United States Department of Agriculture, and the Louisiana Sugar Experiment Station. The work was done at the Station's sugar house and laboratory at New Orleans during the cane grinding season of 1920-21. The authors desire to express their appreciation and thanks to W. G. Taggart, assistant director of the Station, who, by helpful suggestions and actual labor, enabled them to obtain the results described herein.*

Previous investigations at the Louisiana Sugar Experiment Station, the results of which have been published chiefly by Zerban and his co-workers, have demonstrated that filtration of cane juice with the aid of kieselguhr, followed by filtration with active decolorizing carbon, is greatly superior to the older sulfur-lime method of clarification in removing color and other impurities from the juice. The kieselguhr-carbon filtration process was given a trial on a large scale in Louisiana during the past grinding season, and reports indicate that it cannot yet be regarded as a commercial success, although sugar and molasses of excellent quality were produced directly from juice. The chief factor to be considered in explaining why the new process may not yet be successful is the cost of filtering materials, and probably also the costs involved in working the process, as compared with the cheap materials and the low costs of operating the older processes. The chief use of highly activated decolorizing carbons in the sugar industry will probably be confined for the present to the refining of raws.

In view of the above facts, and in consideration of the huge quantities of waste vegetable materials available for the manufacture of decolorizing carbons, it is natural that much interest has been created in the manufacture and uses of such carbons, and we think the belief is justified that high-grade carbons at low cost will be produced in the near future. The subject of the preparation of vegetable decolorizing carbons from various raw materials has been treated in the Louisiana Sugar Station's bulletin 167 (May, 1919) by Zerban, Freeland and Sullivant.

Up to the present very few decolorizing carbons are being produced on a large scale. Several carbons are being developed in this country, however, and at the suggestion of Mr. Paine of the Carbohydrates Laboratory, Bureau of

\* From Journal of Industrial and Engineering Chemistry, Vol. 13, p. 921.

Chemistry, it was decided to test as many of these as possible at the Station's sugar house. Four such carbons were obtained.<sup>1</sup>

#### THEORETICAL CONSIDERATIONS.

Schneller<sup>2</sup> demonstrated the presence of polyphenols in various parts of the sugar cane by means of the well-known color reaction which these give with salts of iron. He concluded that the polyphenols, expressed with the juice and coming in contact with iron already present in the cane or dissolved from rolls, piping, and other sugar-house equipment, cause discoloration of the juice. Schneller also pointed out that the polyphenol-iron compounds are only temporarily bleached by sulfur dioxide and reappear on neutralizing.

Zerban<sup>3</sup> has studied some of the coloring matters of cane and has found that, in the methods of clarification generally practiced in Louisiana, the dark color in cane products appears to be due almost entirely to polyphenol derivatives occurring in cane juices, the color being two to three times as dark when ferric salts are present with the polyphenols. He also points out that under certain conditions the natural coloring matters of cane, anthocyanin and saccharetin, which are polyphenol derivatives, may contribute materially to the color of the juice.

It was found by Zerban and Freeland<sup>4</sup> that decolorizing carbons will remove practically all the color from cane juice, as well as the polyphenols, the iron combined with them, and substances which under certain conditions are capable of producing polyphenols.

In connection with the purification of cane juice there must be taken into consideration the presence of other impurities aside from those which are responsible for color; namely, impurities which exist in the colloidal state. Schneller,<sup>5</sup> and later Zerban,<sup>6</sup> called attention to this subject, and the latter, with others, is of the opinion that cane-juice clarification, whether accomplished by so-called chemical means or by the use of adsorbents, such as kieselguhr and carbon, is to be regarded as a colloid-chemical proposition.

The impurities of cane juice from the rolls may be considered to exist in all degrees of dispersion. The gross impurities, such as soil particles, finely-ground bagasse, etc., are visible to the eye. Some of these may be thrown down by centrifuging, but the liquid will still be opaque. If the centrifuged juice be poured upon a paper filter, some of the suspended matter will first pass through. As the pores of the paper become clogged the liquid will pass through clear, but by this time filtration will have become very slow. If, however, the raw juice

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<sup>1</sup> We owe our thanks to the National Carbon Co., of Cleveland, and to Dr. J. W. Turrentine, Bureau of Soils, U. S. Department of Agriculture, in charge of the potash plant of the Department at Summerland, Cal., for supplying us with 100-pound lots of their carbons.

<sup>2</sup> Louisiana Bulletin 157 (August, 1916).

<sup>3</sup> Journal of Industrial and Engineering Chemistry, Vol. 12, p. 744.

<sup>4</sup> Louisiana Bulletin 165 (March, 1919).

<sup>5</sup> Louisiana Planter, Vol. 56, p. 44.

<sup>6</sup> Louisiana Bulletin 173 (March, 1920).



is brought to boiling with about 2 per cent of its weight of kieselguhr, filtration is rapid, and the filtrate is brilliant and clear, although colored. If juice thus clarified be completely dialyzed and the dialysate evaporated to dryness, there will be found a solid residue which sometimes has a gelatinous appearance and often is nearly colorless. This residue contains both organic and inorganic material, as is shown by ashing. In dialyzing cane juice it has been noticed that a great deal of the coloring matter will pass through a collodion membrane, some of the color being adsorbed in the membrane itself.

Paine and Walton<sup>7</sup> made use of the dialysis method in comparing the efficiency of different kinds of kieselguhr, and it is at their suggestion that this method has been used for a part of the work reported here.

The colloids of cane juice have proved an abomination to the sugar manufacturer. They are thought to cause frothing during evaporation, and then often flocculate and precipitate in the syrup. They retard crystallization, and adhere to the sugar after it has been centrifuged, acting as a binder for coloring matter and forming a film on the sugar crystal which retains moisture, thus offering a favorable medium for the growth of molds and bacteria which brings about decomposition of the sucrose when the sugar is stored. To the syrup maker, on the other hand, the colloids may be regarded as being useful, in that they retard crystallization.

#### SUGAR HOUSE AND LABORATORY RESULTS.

*Sulfur-Lime Process.*—For the sake of comparison with the kieselguhr-carbon process by the dialysis method, three runs by the sulfur-lime process are recorded. These runs were made in the usual way, on about 3000 pounds of juice each, by sulfuring to 5 cc. acidity and liming back to 0.5 cc. Samples of raw, sulfured, and limed juice, respectively, were dialyzed. Each 200 cc. sample of juice, after mixing with a little toluene, was poured into a collodion sack of about 1000 cc. capacity and dialyzed, first in running tap water, then in four daily changes of distilled water. After dialysis, the contents of the sack were transferred and evaporated to dryness on the water bath, heated at 110° for 15 hours, and weighed. This gave total nondialyzable solids. The residues were then washed and reweighed.

The results of this treatment are shown in Table 1, expressed as mg. of nondialyzable solids and ash per 100 cc. of juice. No corrections have been made for change in specific gravity, as this was found to have little effect upon the figures.

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<sup>7</sup> Science, Vol. 53, p. 266.

TABLE 1.—SULFUR-LIME CLARIFICATION.

Run	Solids			Ash		
	Raw	Sulfured	Limed	Raw	Sulfured	Limed
1	366.6	50.1	38.7	11.5	13.3	13.4
2	483.8	44.8	52.3	22.8	15.0	17.2
3	407.1	70.3	51.1	40.4	28.1	21.7

The significant figures of Table 1 are those of the juice after liming, since the impurities remaining at this stage of the treatment are carried through the following steps of evaporation and boiling. In Runs 1 and 3 there is considerable reduction in the amount of colloids by liming, while in Run 2 there is an increase. This increase is probably due to over-liming, it being well known that a part of the precipitate brought down by sulfur dioxide may be redissolved on liming back. No color determinations were made in connection with the sulfur-lime runs.

It is interesting to compare the quantity of colloids remaining in the juice after sulfuring and liming, as shown in Table 1, with those of the kieselguhr-carbon treatment of Table 2.

*Kieselguhr-Carbon Process.*—The kieselguhr-carbon runs were made as follows: To each clarifier of raw mill juice (about 3000 pounds) were added 20 pounds (0.66 per cent) of kieselguhr. The juice was heated just to boiling and filter-pressed. On running clear, the juice was returned to the clarifier and to it were added 30 pounds (1 per cent ash-and-moisture-free basis) of decolorizing carbon. This mixture was again brought to boiling and filter-pressed.

Samples of the mixed raw mill juice and the juice after each treatment were used for the analytical determinations. For dialysis, 200 cc. samples were treated as described in the sulfur-lime process.

The results of dialysis are given in Table 2. The raw mill juice is designated by Raw, the kieselguhr-treated juice by Kieselguhr, and the carbon-treated juice by Carbon. The first column of figures shows colloidal solids remaining after each treatment, expressed in mg. per 100 cc. The second column gives the per cent colloids calculated on the amounts before and after treatment. The last column gives ash in mg. per 100 cc.

It will be noted by comparison with Table 1 that, in general, less colloids are found in the juice after kieselguhr treatment alone than after sulfuring and liming. It may be supposed that liming contributes to the total colloids in the latter process, the supposition being well borne out by comparing the figures for ash. It is also known that the colloids of cane juice are reversible to acids and alkalies.



\* TABLES 2 AND 3.—KIESELGUHR-CARBON CLARIFICATION.  
COLLOIDS BY DIALYSIS AND DECOLORIZATION.

Run	Carbon Used	Treatment	Total Colloids		Ash, Mg. per 100 cc.	Color	
			Mg. per 100 cc.	Per Cent Remaining		Tl. Units 3	Per Cent Remaining
4	A	Raw	152.8	....	13.8	....	....
		Kieselguhr	22.6	14.79	3.3	185.3	....
		Carbon	11.1	49.11	3.0	8.6	4.64
5	B	Raw	129.9	....	18.5	....	....
		Kieselguhr	31.8	24.50	3.2	192.5	....
		Carbon	11.4	35.85	3.7	13.7	7.12
6	C	Raw	225.9	....	12.2	....	....
		Kieselguhr	37.1	16.42	5.1	204.2	....
		Carbon	11.3	30.45	1.9	12.8	6.28
7	D	Raw	182.1	....	14.7	....	....
		Kieselguhr	33.3	18.28	4.9	174.8	....
		Carbon	23.4	70.27	3.9	17.8	10.23
8	A	Raw	407.1	....	40.4	....	....
		Kieselguhr	45.8	11.25	7.9	194.9	....
		Carbon	18.8	41.05	3.6	25.0	12.82
9	B	Raw	327.2	....	56.1	....	....
		Kieselguhr	42.6	13.02	5.2	126.4	....
		Carbon	21.9	74.64	3.4	22.3	17.63
10	D	Raw	243.9	....	27.6	....	....
		Kieselguhr	34.7	14.23	4.5	156.2	....
		Carbon	34.4	99.13	4.5	23.3	14.92

In Runs 4, 5, 6, and 7 of Table 2 the raw juice samples were centrifuged before dialysis in order to remove mud and some of the suspended matter. In Runs 8, 9, and 10 the raw juice samples were not centrifuged. A comparison of these two sets of figures furnishes an idea of the kind and amount of material removed by treatment with kieselguhr alone. There is a variation in the amounts of colloids left after kieselguhr treatment which is no doubt due to variations in the tightness of the rolls in grinding. Such variation may perhaps also be explained by changes in the condition of the cane, part of which had been exposed to several frosts.

*Colorimetric Determinations.*—Table 3 contains the results of colorimetric determinations. These were made with the Hess-Ives tintphotometer in the manner described by Meade and Harris,<sup>8</sup> the table worked out by them being used for translating scale readings of the instrument to units of color. The seventh column

\* Condensed. For complete tables see original article.

<sup>8</sup> Journal of Industrial and Engineering Chemistry, Vol. 12, p. 686.

contains the total color units, divided by 3, and the last column shows the percentage of this total left in the juice after carbon treatment.

Two runs were made with each carbon, but through a mishap at the sugar house the second run with Carbon C was lost.

A variation in decolorization is particularly noticeable in Runs 4 and 8, in which Carbon A was used, and in Runs 5 and 9, where Carbon B was employed. In attempting to explain this we would point out that in the second runs with each of these carbons a greater amount of total colloids was present in the juice after kieselguhr treatment in each case, which no doubt interfered with adsorption of coloring matter.

It is probable that as the amount of total colloids increases, the decolorizing power of any carbon is diminished.

The molasses from the carbon runs contained material in suspension which settled out upon standing. A similar precipitate had been observed previously by Coates and Slater<sup>9</sup> in syrup from sulfur-lime treatment. We made a partial analysis of our precipitate from molasses after freeing it from soluble matter and found it to contain 75.93 per cent ash. The ash contained 52.22 per cent silicon dioxide, 15.61 per cent ferric oxide and alumina, and 10.23 per cent calcium oxide. Qualitative examination showed the presence also of phosphoric acid, magnesium oxide, and a considerable amount of copper. These findings are in qualitative agreement with those of Coates and Slater. We also obtained a strong reaction for manganese.

The proportion of carbon used in the above experiments, 1 per cent on the weight of juice, is perhaps the lowest that it is profitable to use in most cases.

#### REPEATED USE OF CARBON.

In first reducing the juice to syrup as practiced at most of the sugar houses, or in refining raws, the proportion of carbon used is about 5 per cent based on total solids, which is nearly the same as our 1 per cent on juice. In order to gain a knowledge of what might be expected from repeated use of any particular carbon we made the following simple laboratory experiments, since the limited amount of cane available would not permit such tests to be run at the sugar house. Two hundred cc. of juice, first clarified with kieselguhr, were treated with 2 g. of decolorizing carbon, heated to boiling, and filtered by suction. When sucked dry the carbon was transferred to a second 200 cc. of juice, and the heating and filtration were repeated. The second filtration was in each case very much slower than the first, and on the third treatment, filtration was very difficult in most cases. Color determinations were made on each filtrate and the color units found by the use of the table of Meade and Harris.

The results of these experiments are shown in Table 4. Very good decolorization was obtained by a second filtration with Carbon A, while with Carbons B, C, and D, little or no decolorization was obtained. By a third filtration, not only was filtration very slow, but coloring matter was actually washed out of Carbons B and D. It was practically impossible to filter Carbon C on third treatment. It would seem to be unprofitable to use less of the three latter carbons

<sup>9</sup> Journal of Industrial and Engineering Chemistry, Vol. 8, p. 789.



for cane juice decolorization than in the above proportions, while with Carbon A fair results might be expected with half this quantity.

\* TABLE 4.—REPEATED FILTRATION WITH SAME CARBON—COLOR REMAINING AFTER FILTRATION.

	Total Color Units Divided by 3			
	Carbon A	Carbon B	Carbon C	Carbon D
Before carbon filtration....	112.0	112.0	112.0	112.0
After 1st filtration .....	51.5	73.0	68.6	71.1
After 2nd filtration .....	78.5	104.8	110.0	115.9
After 3rd filtration .....	114.4	117.5	....	141.4

#### SUMMARY.

1. Sugar-house and laboratory tests were made on four decolorizing carbons.

2. Tables are given which show the amounts of solids and ash left after sulfur-lime and kieselguhr-carbon treatments. In general, fewer colloids were found after the use of kieselguhr alone than after the sulfur-lime treatment.

3. Colorimetric determinations were made on the juice treated with the four different carbons.

4. Tests were also made of repeated use of the carbons. In the case of one carbon only, was good decolorization obtained on a second filtration.

\* Condensed. For complete table see original article.

[W. R. M.]

## Report of Committee on Mill Equipment.\*

By W. v. H. DUKER.

### MILL EQUIPMENT.

The price of a product is determined by the law of supply and demand.

With an oversupply of the product, in the manufacture of which we are interested, and no immediate prospect of an increased demand, the price is bound to be low for some time to come.

During such times everyone who has the interest of the sugar business in these Islands at heart needs to do his utmost to assist in maintaining it as a dividend-paying industry.

We might therefore begin by asking the question: "Do we, or do we not, put the sugar in the bags in the most economical way?"

But as the answer to this question would require much more information than we may hope to supply with our limited knowledge of the industry as a whole, we are forced to confine ourselves and limit the investigation to "Do we operate our mill equipment economically, and do we judge rightly about our methods of operating?"

For years past we have been looked upon as leaders in the sugar industry on account of the marvelous results obtained in our milling plants. Our rise to the top has been very rapid, and therefore it is possible that we did not get quite as firm a hold of the underlying principles as others who advanced at a little slower rate.

In Hawaii, we have always had peculiar conditions, due to climate, labor, position in the world, etc. This has been the cause of our having developed methods of our own, in field work, dealings with labor, factory operation, selling our product, and even in our chemical control.

It is, therefore, only a natural consequence that from all over the world men come to study our ways.

Their first impressions are generally very favorable, our climate appeals to them, and they are delighted with the way in which they are received with true American hospitality. And thus they express themselves as highly pleased, and make us believe that we are far ahead of all others and that we have little to learn as producers of sugar.

However, after our visitor sails away, and has time to think over what he has seen and heard, he often changes his first impressions; but of that we hear little or nothing.

Therefore, instead of giving a review of our mill equipment you will find in the following pages a criticism of experienced Java engineers on the use we make of it, and finally some opinions of our own men who have handled this machinery for the last ten or twenty years.

I have had the good fortune to come in contact with a few of our recent visitors, and, besides, I have studied articles written by some of them after their

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\* Presented at the Nineteenth Annual Meeting of the Hawaiian Chemists' Association.

return home; and as I have often heard it said that the object of these meetings is to encourage discussion on subjects of interest to the operating staff of the sugar mills, I would like to begin by relating a little experience I had not so long ago.

After taking a Java engineer around to several mills on Hawaii, and knowing that he had visited practically every mill on the other Islands, I asked him to give us his frank opinion and impression of our mill equipment and of our methods of operating it.

His answer was, "that he was much impressed, very much impressed indeed, especially with the willingness of the owners to spend money on equipment," and he added that "if you do recover the extra sugar (due to high extraction) it must cost you a lot of money to get it."

We can, of course, ignore this statement and say: "How dare he make such an assumption? We, with our high extraction, and the people of Java with their old-fashioned mills."

But undoubtedly there are others who question if we obtain our much-advertised milling results in an economical way, and it surely will do us no harm if we listen to what they have to say. Besides they are discussing our methods among themselves and have no particular interest in our affairs.

In a separate report,\* therefore, are two translated articles, one by Mr. F. W. Bolk, of the Java Experiment Station (who needs little introduction after his personal visit in 1910, and the publication of a voluminous report on the sugar industry in Hawaii), and another by Mr. L. W. Hofland (the original of which appears in the *Java Archief*, No. 24, of June, 1920).

In both these articles our equipment is admired and envied, but our methods of operating, as well as our methods of control, are severely criticized.

When studying these articles we notice first of all that both in Java and in Hawaii the term "extraction" has been the cause of much misunderstanding. We realize, of course, the fallacy of this figure as a factor for comparison; in fact, this term has caused us a terrible lot of trouble, so much so, that several engineers have lost their positions on account of it; others have actually destroyed machinery in their futile attempt to reach the impossible. Now we cannot say that we did not know, because Dr. R. S. Norris, formerly of the Experiment Station staff, told us long ago, when he introduced the factors for milling loss and extraction ratio to be used instead, and Mr. Horace Johnson explained it in a lecture held for plantation men in October, 1919, and published in the *H. P. Record* of January, 1920.

"Of course, a 'high extraction' means much to the plantation if only we realize that the head luna has as much to do with it as the boy who carries the samples, but never should this term be used to judge the capability of the engineer in charge, or the efficiency of the equipment."

Therefore in this study of our milling efficiency we may well begin to note what Mr. Bolk remarked in 1910. He wrote thus:

"The higher extraction figures (considered apart from the actual better mill work on Hawaii) are partly due to:

- (a) The relation of the juice purities in connection with the Brix of the first mill juice.

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\* Report of the Committee on Manufacture of Sugar and Utilization of By-products—Hawaiian Sugar Planters' Association, 1921.



- (b) Probably too low a figure for fiber.
- (c) The fact that Hawaiian cane holds less water per 100 fiber. Moisture contents in bagasse from 40 to 42% in cane with equal fiber content are constant exceptions with us."

And if this be true, let us watch out and not measure our efficiency as sugar manufacturers by the sucrose extraction alone.

We may follow with what Mr. Horace Johnson refers to in his report on sugar manufacture to the Hawaiian Sugar Planters' Association in 1918 and published on page 252 of the proceedings. He says there: "We would call your attention to another source of loss due to fermentation, viz., that due to dirty conditions around the mill. This loss does not appear in our undetermined quantity, nor is it taken into account by our methods of control. That it should be seriously considered will be seen from the following extract from a report of the work done in the Java mills which carry on a much more complete control of the mill work than we do:

"It has been observed that the mill control, as required by the Java Experiment Station, was much too troublesome for practical use, and that considerable simplification might be considered. The result of recent deliberations was, however, that the figures required were really necessary to obtain a good insight into milling work, and that it was obligatory to collect these data in order to serve as a basis for improvement as soon as a falling-off in the efficiency of the mills was noticed.

"An example of the excellent results of careful mill control is given by the fact that large losses of sugar, which until recently escaped detection, are now brought to light by the close control. It was originally the custom to ascertain the amount of sugar in the juice and in the bagasse, and to consider the amount of sugar in the cane to be the sum of the two, making no allowance for unaccountable losses during milling. The new control records the amount and the sugar content of the different mill juices separately, and that of the total of the mixed juice; and it found in many instances that the amount of sugar in the mixed juice was smaller than that of the sum of the component parts. This strange phenomenon could not be ascribed to a personal error, as the weighings and determinations were all made on the same scales, with the same instruments, and by the same individuals, and yet it always tended in the same direction.

"It was found that in the tanks, gutters, collectors, etc., of the juices, especially those of the maceration with the last mill juice, such huge amounts of bacteria, yeasts and fungi could accumulate that large quantities of sugar, amounting to as much as 6% of the total quantities, were lost by inversion.

"The new control can detect these losses, which may be rather easily overcome by continually cleaning the conduit through which the juices pass, or even by using double sets of tanks, suction pipes, collectors, stone-catches, etc., of which one set is cleaned and disinfected while the other one is working. This rather simple device has already reduced these unaccountable losses in many factories to an insignificant fraction of their former sum, thereby proving that they had really existed, and were not a consequence of errors."

We had more of such warnings when at last year's meeting before the Sugar Planters, Mr. J. N. S. Williams read a report on a milling problem (page 32, proceedings) which we probably would call a control problem, but it is a serious charge against our official methods of control. We simply say, the sucrose in the mixed juice plus what we have found in the bagasse constitutes the sucrose in the cane, and if there are any additional losses in the mills we do not recognize

them. But from the above we see that we can no longer afford not to recognize these losses, for it may mean the difference between working at a profit or at a loss; and it appears to me that this loss is large enough to neutralize any advantage gained by the extra extraction obtained through the introduction of the Messchaert grooves, and that we are wasting the royalty money.

Again, we cannot excuse ourselves by saying that we did not know; we have had warnings enough, even if it had only been the songs of the "Piffle Mill Staff" relating to the ever-increasing stream of "cush-cush" coming down the rollers and souring our mills.

Referring further to the annual synopsis of Mill Data for Java of 1919, and in connection with the losses mentioned above and the loopholes in our methods of control, may I submit the following comparison:

DIFFERENCE IN PURITIES BETWEEN FIRST MILL JUICE AND MIXED  
JUICE — HAWAII SYNOPSIS, 1920.

	First Mill Juice Purity	Mixed Juice Purity	Difference
Puunene .....	88.91	85.90	3.01
Oahu .....	87.2	82.84	4.36
Ewa .....	83.1	79.19	3.91
Maui Agr.....	90.11	86.67	3.44
Pioneer .....	88.98	85.86	3.12
Hilo Sugar Co.....	87.41	85.18	2.23
Onomea .....	88.6	85.2	3.4
Olaa .....	86.9	83.1	3.8
Hawaiian Sugar Co.....	88.67	85.66	3.01
Hakalau .....	88.6	85.0	3.6
Wailuku .....	89.22	85.05	4.17
Waiakea .....	87.10	83.88	3.22
Honokaa .....	87.36	82.81	4.55
Pepeekeo .....	87.68	83.42	4.26
Paauhau .....	88.1	82.7	5.4
Honomu .....	88.6	85.0	3.6
Average .....	87.91	84.22	3.69
JAVA SYNOPSIS, 1919			
<i>All installations of Crusher and 12 R. M.</i>			
Bangsol .....	84.9	83.3	1.6
Brangkal .....	83.9	82.4	1.5
Djati Carang .....	81.1	78.9	2.2
Djati Carang .....	82.1	79.4	2.7
Djatiwangi .....	83.7	81.1	2.6
Kentjong .....	82.4	79.7	2.7
Meritjan .....	83.0	80.6	2.4
Selovedjo .....	86.8	84.8	2.0
Tanjoenan .....	86.6	84.5	2.1
Average .....	84.2	82.2	2.0

The true average difference for 24 Java mills equipped with crusher and nine-roller mills is 1.9.

The placing of the sugar in the bags is directly in proportion to the purity

of the juice, and therefore these figures are important and show clearly that it is high time to tear ourselves loose from the term "extraction," and talk more about recovery—that is, the percentage of the sugar delivered in the bags.

Part of these differences is due to losses by fermentation, and in several factories they have succeeded already in reducing this loss materially. But part of this drop in purity may be due to qualities of the cane or the leaves, sampling of the juices or methods of analysis.

There are several matters not removed from the cane by pressure, and not considered as belonging to the juice, which are removed when subjecting this cane to extraction with water.

Referring to the above paragraph, it is not unlikely that a part of this large difference is due to our method of milling—that is, to the large dilution. From Bolk we have the following:

"When bagasse is subjected to a high pressure in a hydraulic press and not extracted, then, after the first drop in purity, juice is recovered from the bagasse with an equal or *higher* purity as the pressure increases." That was found to be the case on Hawaii, and I have on record the results of different tests which I have discussed in another chapter.

With a purity of last juice of 83.8 in a test without maceration, the residual juice as determined with a Soxhlett apparatus was 67.9; another test gave 85.7 and 69.6. But here in Hawaii, too, many have recognized that the juice must be removed by pressure and the sucrose must not be obtained by washing it out. Mr. John Greive, engineer for the Hilo Sugar Co., gives this view, in an article written by him and appearing on page 56 of the H. P. Record of August, 1920, when he writes: "The fundamental principle of milling is the extraction of the juice from the cane by means of pressure, and, in the opinion of the writer, the point of primary importance in high class mill work is the proper and effective application of that pressure."

Bolk writes on this:

"The results of the mutual control (weekly comparative mill data of Hawaii) show clearly that there is no reason to expect results from a much higher maceration, and the most contradictory figures may be grouped together. Personally I am convinced that many factories macerate too high. It looks to me that even on Hawaii, for crusher and four mills, they do not need to go beyond 30%, and only then when the water is divided over the second and third mills. With three mills a maceration of 20% should be sufficient in general. That higher maceration can be applied, for more mills, is self evident, provided the water quantity is spread over more mills. Nearly all factories practice return juice maceration, and I am sorry to admit that in Java, with our different work in the first part of the mill train, it would not always prove to be an advantage; for Hawaii, with the better preparatory work, I believe it is. Yet I do not consider it of any definite advantage to carry this so far, and to apply for four mills the theoretical rational system, as do a few factories on Hawaii, behind the first mill the juice from the third mill, behind the second mill the juice of the fourth mill, behind the third mill water. For excessive high maceration, behind the third mill in one dose, there may be a good reason. This diluted juice is practically a mixture of juice and water, and thus the excess of water which never did anything in the fourth mill may then be used in the third mill. But I would think that, when the same quantity was divided, two-fifths behind the second mill and three-fifths behind the third mill, and only the diluted juice of the fourth



mill would be returned behind the first mill, better results would be obtained. In fact now and then they seem to forget that returning diluted juices is contrary to the first principle of sugar making—removing the juice from the mill as “quickly as possible in order to lime and heat it.”

And thus the further we go into the subject the more we see that it is much more a question of operating than one of equipment, and to show that others in these Islands hold this view I refer to the statement made on page 240 of the proceedings of the Thirty-eighth Annual Meeting of the H. S. P. A.:

“These excellent results have not been obtained by the general installation of new machinery, but by the more efficient operation of the old equipment.”

In a report to the Planters in 1905, Mr. C. C. Kennedy gives a review of the history of the sugar industry in these Islands; he says: “As the sugar price of 8c a pound belonged to the past, and there was every indication of a further drop, it was clear that everything needful should be done to bring to market a larger part of the sugar originally present in the cane.” And a little further: “A couple of seasons later the Honolulu Iron Works, under Mr. C. Hedemann, built such a mill (nine-roller mill with hydraulic pressure), and the first one was erected at Honomu in 1897. From then on a crusher and nine-roller mill was considered the standard equipment.”

I especially draw attention to this statement because today there are a few mills with this very same simple equipment getting as high results as the best.

It appears to me, therefore, that there remains quite a bit to be learned in this sugar producing industry, and the sooner we all realize this the better for us; and whilst in the mood to receive instruction let us have in mind those wise words of the late Mr. Gartley: “If you want to make a success of business you must look around and study how your successful neighbor does it.” And when the question comes down to the ways of handling the equipment we have at our disposal, can we also hold our own? By all means let us be open-minded and see then how others do it and what they say about our ways.

*“The Puunene Mill.”*—The idea embodied in this construction is the result of remarks made while the mill was operating, and checks perfectly, as we will see later, with the Hawaiian method of milling. It had occurred to them that the top brasses would wear more on one side than on the other, because the pressure between back roller and top roller is greater than between feed roller and top roller. The resultant of both forces does not run in a vertical direction, in which direction the top roller *should* move against the hydraulic pressure, but in a slanting direction towards the front roller. It was then noticed that the top brasses tipped and were likely to become jammed in the cheeks, causing the hydraulic pressure to work irregularly and with shocks, because of not responding quickly enough. To meet this condition a mill was constructed whereby the top roller did *not* move vertically in the cheeks, but slanting in the direction of the resultant of both forces, or towards the feed roller.

It appears to me that they tried to correct a mistake originating in the idea in Hawaii that the front opening should be such as just to allow for a certain grinding capacity, and then to do all the pressing with the top and back roller, whereby the above mentioned conditions becomes much worse than it

ought to be. And it would be far better to construct the mills in a way whereby a position is obtained which allows the resultant of the forces to be as near vertical as possible. Because, if the top roller was exactly between the two lower rollers, then we could be sure that both rollers would do equally as much pressing, and the mills would work most economically and without chances of jamming the top brasses."

Now I know full well that in many of our mills we make the mistake referred to above, and I strongly recommend the study of the before mentioned articles, which explain in detail the following few points, most of which are admitted by our own practical mill engineers to be steps nearer to an economical operation of the milling equipment:

1. That better results are obtained and the machinery subjected to less wear when grinding a heavy blanket under a slow circumferential roller speed than a thin blanket under a high roller speed.

2. That the top roller brasses must lift perpendicularly in the housing without any tipping or side friction.

3. That the strain in the mill housing must be divided equally and symmetrically in the housing.

4. That reabsorption of juice can be decreased by opening of the back roller and that setting up of the back roller beyond a certain limit gives no better results. Or, if we prefer to take counsel from men who have worked in our midst, I may quote Noell Deerr, who found that:

"Juice extraction by single pressing up to a very high pressure is much inferior to juice extraction by repeated pressing under a much lower pressure." In other words, that grinding as we do by operating a two-roller mill in a three-roller mill housing is not an economical way of using the equipment.

Or the following statement by Mr. John Greive, page 66, H. P. Record, August, 1920:

"There is still some difference of opinion amongst engineers with regard to the speed at which mills should be run to do the best work. Some maintain that high surface speed of rollers with thin blanket is the correct method, while others agree with the writer, that, providing juice drainage is sufficient, just as good results can be obtained at the same tonnage ratio with low surface speed and correspondingly thicker blanket."

The answer to the first question, then: whether or not we use our equipment in an economical way, you will find best expressed in the contributions sent in by several mill engineers, copies of which are attached hereto.

The second question: whether we judge rightly on the method of operating with our present methods of control, I think needs to be answered in the negative, and I believe that a revision of our present official methods is sorely needed. We will then probably find that any improvement therein should not be confined to milling only.

The encouraging part in this criticism of our work is the realization that the steps which need to be taken are those which will help to increase the efficiency of the human element rather than that of the machinery, and where this

is in accordance with the conclusion arrived at by men in our community whose life work it is to help to improve the social condition, it is all the more gratifying that this comes up in a time when the industry is temporarily suffering under the stress of a low sugar price, which makes any installation of new equipment a real hardship, especially if we must admit that we do not yet know all about using the old equipment in the most economical way.

W. V. H. DUKER,

*Chairman, Committee on Mill Equipment.*

*Comment by Mr. Herbert Walker:* When our Javan friends have shown that they are able to get high extraction, we may believe they are keeping it low purposely. The remarks of Prinsen Geerligs on this subject are illuminating. (Int. Sugar Journal, June, 1920, p. 322, "The 1919 Java Sugar Crop.") "The moisture content of the bagasse is rather high . . . average 47.01 per cent . . . The sugar extraction in juice on 100 parts of sucrose in cane is also not particularly good, being 92 per cent; this gives rise to some disappointment because the arduous work done by the Technical Department of the Java Sugar Experiment Station in connection with the improvement of the milling plants had led us to believe that, especially in a year when small amounts of cane had to be worked up, a considerable rise of that value might be witnessed. The figure has been decreasing since 1917, and is not now much higher than in 1910, when it amounted to 91.2 per cent."

The following are the before-mentioned contributions and comments received from several of the local mill engineers and chemists:

*From Mr. John S. K. Cushingham, Engineer Honokaa Sugar Co.*

In answer to your letter of September 13th, referring to my results of the trial on the Java engineers' report on milling, I have the following to say: That we can do the same quality and quantity of work with our mills using less power.

After hearing the report from Java engineers and their method of reasoning on cane milling, I decided that I could give their ideas a trial with but few changes. The top caps had already been adjusted sufficiently to allow for the brasses to lift perfectly perpendicular, which made the resultant of the forces lifting the top roller, running perfectly in the center of the mill housing. The engine speed was reduced, and to mill the same amount of cane a thicker blanket was put through. The mill openings were not increased, but four accumulator plates were removed, which lessened the hydraulic pressure by 36.8 tons, to allow for the thicker blanket.

Resulting from the trial, I found that much engine and mill friction has been eliminated. Now I am making more trash and having better results in the fire room.

Heretofore there was more exhaust steam than could be used; now, with the slow engine speeds, I find that we can forget about the exhaust we had to blow off to the atmosphere.

Messchaert grooves are very essential with this slower mill speed and thick blanket to allow for the draining of the juice.

The boiler pressure runs from 85 to 90 pounds pressure. The crusher gear-



ing pedestals broke from an accident a few months ago, and I am handicapped by not having the use of the crusher. All the crusher can do now, until we install the new one, is to level the feed. Without the crusher working we have a twelve-roller mill.

Following is the data for weekly averages for three weeks before and after the test:

Week Ending	R. P. M. Main Engine	Weights per Lineal Foot	Tons Cane per Hour	Bagasse		Milling Loss	Extra Ratio	Dil.
				Sucrose	Moisture			
Aug. 6 ...	76	72	37.85	1.49	41.49	2.64	.24	35.3
Aug. 13 ...	76	72	37.07	1.57	41.86	2.81	.28	33.2
Aug. 20 ...	80	72	36.86	1.89	42.47	2.41	.25	33.1
Sept. 3 ...	64	66	38.00	1.41	41.96	2.51	.25	32.1
Sept. 10 ...	65	65	37.59	1.42	42.02	2.54	.25	34.7
Sept. 17 ...	66	65	37.47	1.34	41.51	2.37	.24	32.9

*From Mr. J. W. Kennedy, Engineer Pepeekeo Sugar Company:*

In answer to your request I will try to give you a description of our mill equipment at Pepeekeo.

The weight carried on hydraulics is 380 tons. Pressure on rollers per lineal foot, 76 tons. Speed of rollers in feet per minute: First mill, 17.927; second mill, 19.671; third mill, 21.580. Revolutions of engine per minute, 50. Tons fiber per lineal foot per hour, .581 ton. The latter figure was obtained by taking the tons cane per hour to date this season, the average for the season being 23 tons per hour.

I have always made it a practice to keep my mill in first-class condition. In the off season I look after everything that may give bother during the grinding season, and so obviate stoppages during the progress of the crop. Our stoppages last season from breakdowns only amounted to 45 minutes, and this was caused by an occasional chain link or carrier slat breaking, and sometimes a piece of iron in the mill.

To obtain the best results in extraction, I find that it is best to stand around and observe things, and so increase the opportunities for improving conditions. The rollers and juice grooves are also kept in good condition. For the past six years the extraction has been slightly raised annually—96.89, 96.97, 97.05, 97.50, 97.97, and 98.13—but in order that good results may be obtained in extraction it is necessary that grinding should be uninterrupted.

I do not offset the hydraulic jacks and have no tipping up of brasses. The top roller is kept so steady while in operation that the only way in which any motion in the brasses may be detected is by placing one's finger on them. You probably have placed a bar of half and half solder in the middle of the bagasse blanket and caught it as it came out on top of the bagasse roller and examined its thickness. In the last mill here it comes out  $3/32''$  thick. Before passing this piece of solder through we stop the mill as it stands, clean away the bagasse

blanket for about a foot and place the bar of solder at the entrance of top and feed rollers.

I find better results from using hot maceration water. We take the water from the last effect of the evaporators and feed by a steam nozzle at the entrance to the Ramsay scraper. The water is heated to 202° Fahr. Some engineers object to this system, claiming that it makes the mill slip or causes roller shells to shift. I have had no trouble from either, but I do find that it helps in extraction.

The first factor in a mill, however, is to have the men trained to carry out the orders as given to them. Our mill and boiling house have been painted throughout at considerable cost for paint, but it makes the place look good and every man seems to take an interest in keeping things clean. Each man has his instructions to see that his department has been properly cleaned before turning it over to the man on the next shift.

*From Mr. E. K. Horkes, Engineer Waiakea Mill Company:*

Am in receipt of your very interesting communication of July 22. In reply to your request regarding my opinion of our method of milling in Hawaii as compared with the method practiced in Java, have the following to say:

If we stop to consider that sugar mills are operated for the purpose of paying dividends to their stockholders, and that the manufacture of sugar is only a means of obtaining that end, we may look at the things in a different light.

Let us take first the method of milling practiced in Hawaii. Our bagasse rollers are invariably screwed as tightly as possible against our top rolls. This method, as we all know, is very destructive to the shells of both rollers, as well as brasses and roller pinions. While off-setting our jacks equalizes to some extent the pressure applied to the two bottom rolls, it does not equalize the friction between the two sides of the top brass and the mill housing. That enormous friction is present is evident from the fact that in the majority of mills obtaining a high percentage of the sucrose in the cane, scarcely a season passes without the breakage of some part of the mills, and a material decrease in the life of rollers, brasses, and pinions. While some of these breakages are due, no doubt, to the crystallizing of the metal, the majority of them are due, the writer believes, to overloading and jamming.

The method of compound maceration certainly aids in obtaining a high extraction with a minimum amount of water being used, starts fermentation in the raw juices with a material decrease in the purity of the mixed juice before it is limed and heated.

Let us take now the method of milling practiced in Java, where the openings between the feed and top rollers and bagasse and top rollers are almost equal. Undoubtedly there is a big decrease in the power required to operate these mills. With an opening between bagasse and top rollers a closer setting of the feed roller must be obtainable, resulting in a more equal distribution of the work done by the two bottom rollers. While the writer has no data at hand, the life of a roller shell or mill pinion must be many times that of one in Hawaii.

*From Mr. William Wyllie, Engineer Onomea Sugar Company:*

The milling equipment at Onomea consists of 14-roller train with shredder.

The mill might be termed as a heavy duty design, steel housings, steel top caps, steel side caps with rigid king bolts, roll shafts mostly carbon steel with increased journal diameters. Roll dimensions 32" x 66" medium and soft texture, juice grooves 3/16" wide, 1 3/4" deep, 2" pitch on feed rolls, 5/32" wide, 1 1/4" deep, 2" pitch on discharge rolls.

The past few years our extraction has increased year after year, irrespective of the quality of cane, there being quite a number of reasons for this: First, the boiling house, remodeled in 1914, new evaporators and pre-evaporators installed, which allowed an increase of maceration water from 20% to 40%. Second, new boilers, allowing an increase in steam working pressure to 125 pounds per square inch. Third, new mill steel housings and caps complete, rolls with small journal diameters discarded, replaced with new shafts of greater diameter. Fourth, cane shredder. Fifth, two-roll crusher ahead of shredder, dimensions 28 1/2" diameter, 60" length, equipped with five juice grooves 1/2" x 2 3/4" x 12" pitch on bottom roll.

With a mill of the above type, how should an engineer proceed to obtain that confounded extraction? The only method to obtain this high extraction is close mill settings, and speed up for the desired tonnage of cane; say 30 lineal feet per minute surface speed of rolls, with hydraulic load of 80 tons per lineal foot width of roll, should be about normal running. We all know what bagasse is, but did we ever consider its high elasticity as regards to milling? For instance, our shredded cane entering first mill will average about fifteen inches in depth of blanket feeding into small opening. There must be some reason for this, which is absolutely on account of the elasticity of the material. This being true, it is then demonstrated that bagasse is highly elastic and can be fed to mills with close settings. In theory, as well as in practice, take a layer of bagasse of a certain thickness under pressure and another layer of bagasse of greater thickness under the same roll pressure, will the mean pressure to which the whole of the bagasse is subjected be the same in the two instances? The answer is no, for the simple reason bagasse is highly elastic and there is sufficient resistance in a layer of it to diminish considerably the pressure in the center of the blanket. It follows, therefore, that any feed of crushed cane, or shredded cane, giving a layer of bagasse beyond the thickness at which the difference in pressure may be disregarded necessarily leads to lower extraction.

Hence, a thin layer of blanket passing at high speed between the points of application of pressure of rolls is the correct method. The bagasse must give up what it is going to part with, no matter how short a time may be the contact as it passes between the rolls. This method is nothing new, but nevertheless correct.

There being no standardization of mill settings, this depends entirely on texture of rolls for feeding, also returner bar setting, and some cases high fiber in cane. Keep setting as close as possible just to choking point with the desired tonnage of cane. The forward mills in some cases can be set closer than the following, so long as the mill feeds, close opening accordingly. Discharge rolls usually are set close, provided top and bottom rolls are of about the same diameters. Occasionally there is a danger of slippage should rolls be of hard texture; in this case setting up screws can be eased off a little to overcome this without materially lowering extraction.



The extraction we now have on record required heavy type mill housing, rolls of about equal diameters and properly tuned up, equipped with crusher and shredder. Continuous operation of plant, which is very important, with blanket of bagasse about the same thickness throughout the whole train. Hot macerating water not less than 40% ; juice grooves kept clean, which requires two to three sets of scrapers per roll. Observe that hydraulics are working freely and mill moaning a little ; be sure it's on the job ; also observe that rolls don't get out of linement by bearings wearing or heating, it being absolutely essential to keep rolls level to relieve excess friction.

Juice grooves in bottom roll of Krajewski crusher have been quite an improvement, the idea being to prevent juice from squirting, but it was also observed an improvement in feeding and a decided gain in extraction.

The question of an economical extraction could be answered in a hundred different ways, and is a delicate subject to touch on, it being entirely up to the proper party responsible for the maintenance of the plant. The engineer's object in mind must be to obtain the highest possible extraction with the existing equipment. Onomea is entirely self-supporting on bagasse fuel, no waste molasses or any other substitutes used, and operating under these conditions spells economy.

*From Mr. Y. M. Jaouën, Engineer Laupahoehoe Sugar Company:*

Referring to the part in your letter where you say that you have felt doubtful whether the extra sugar extracted does land in the bags, I have for some time felt that way myself. All mills have been crazy after extraction, regardless of anything else. I cannot account for the purity of the mixed juice being lower at the present time than it was a few years back. However, in our particular case, it may be the large amount of dilution we are using this year. We try as much as possible to keep our mill beds clean, by steaming out all around every morning and evening, when grinding night and day, and every noontime while grinding day only. The only effective way to remove the slime around the mills and juice strainers and troughs is to use boiling water under good pressure, but it is impossible to keep pumping water in the juice in order to wash away the slime, so we do the best we can with steam. This keeping the mills clean is a problem to overcome, which is bothering quite a number of engineers.

Regarding the use of the second pressing water for maceration, I have for a long time been against its use. I believe whatever sugar there is in it is sour before it reaches the mill, and therefore does more harm than good.

I note your questions regarding the mill openings. I believe in keeping the feed roll as close up as possible as long as it will feed, the closer the better, but there is a point where we cannot go further, as we have to put through so much cane per hour. The best result, of course, is obtained by slow grinding, but in our case we are expected to put through the mill all they can supply us, so having only a certain size mill, we have to run accordingly. The best result is obtained with a mill of this size by grinding 24 to 25 tons per hour, and we have often done 30 tons day after day. In our mill, under present conditions, with only 80 pounds of steam on the engines, we have to drive the mills beyond the speed they ought to run ; otherwise the engines would stall twenty times a day. As it is, we are forcing our Corliss ; one revolution it cuts off, the next it takes steam full

stroke, thereby jarring the whole engine. By closing the feed and backing off the discharge roller the difference in power owing to the change would not be noticeable.

I am satisfied we haven't sufficient power on our mills, owing to the reason given above.

Through several tests, made by cutting down the maceration, we have always found that the extraction went down. What the result would be if we had the power to turn our mills, and with less maceration, I cannot say. But it is my intention, when we have the new boilers set up, to make tests and find out just how we can obtain the best result.

I quite believe the oftener the blanket is brought under repeated pressure the better, but I also believe that it requires more than a nine-roll mill. With a twelve-roll mill the mill extracts the juice that we have to do with water in a nine-roll mill.

*From Mr. F. Foster Hadfield, Chemist Hilo Sugar Company:*

The following figures show the relation between delays and sucrose recovery :

	1921		
	Second Period	Third Period	Fourth Period
Total recovery .....	91.846	92.158	91.236
Total time lost by delays ...	54 hrs. 50 min.	25 hrs.	82 hrs. 45 min.

*From Mr. Eliot, Chemist Paauhau Sugar Plantation Company:*

The following data all have more or less bearing on theories discussed in this report:

PAAUHAU SUGAR PLANTATION COMPANY  
*Nine-roller Mill*

Crop	Crusher juice	Mixed juice	Decrease in purity	Syrup	Increase in purity	Last mill juice	Diff. btwn. crusher and last mill juice	Extraction	Dilution
1908 .....	88.15	86.37	1.78	89.13	2.76	79.38	8.77	92.69	16.39
1909 .....	90.91	87.60	3.31	90.36	2.76	80.70	10.21	92.71	17.27
1910 .....	89.18	86.26	2.92	89.54	3.28	81.94	7.24	91.06	15.19
1911 .....	90.33	87.66	2.67	89.58	1.92	80.48	9.85	91.45	9.76
1912 .....	89.51	86.87	2.64	88.82	1.95	79.10	10.41	92.35	19.56
1913 .....	90.29	86.50	3.79	87.97	1.47	78.12	12.17	92.98	40.10
Average .....	89.73	86.88	2.85	89.23	2.35	79.95	9.78	92.21	19.71

*Twelve-roller Mill.*

1914 .....	88.93	83.67	5.26	86.67	3.00	68.75	20.18	96.27	36.30
1915 .....	89.62	84.76	4.86	87.13	2.37	68.45	21.17	96.88	32.78
1916 .....	88.59	84.96	3.63	86.52	1.56	67.78	20.81	97.61	39.00
1917 .....	90.33	86.13	4.20	88.06	1.93	68.92	21.41	98.05	42.27
1918 .....	87.51	82.17	5.34	84.50	2.33	65.66	21.85	96.79	28.81
1919 .....	88.26	83.46	4.80	85.15	1.69	71.36	16.90	97.43	36.30
1920 .....	88.10	82.70	5.40	84.80	2.10	69.60	18.50	97.53	40.28
Average .....	88.76	83.98	4.78	86.12	2.14	68.65	20.11	97.22	36.53

## HAWAIIAN FACTORIES' ANNUAL SYNOPSIS—SUMMARY

Crop	Crusher juice	Mixed juice	Decrease in purity	Syrup	Increase in purity	Last mill juice	Diff. btwn. crusher and last mill juice	Extraction	Dilution
9-roller Mill 1910	88.86	86.25	2.61	88.44	2.19	79.25	9.61	92.91	25.91
9-roller Mill 1920	86.98	83.58	3.40	84.91	1.33	70.96	16.02	95.82	39.07
Increase or decr'e.	.....	.....	.79	.....	.86	.....	6.41	2.91	13.16
12-roller Mill 1910	90.20	87.21	2.99	88.61	1.40	78.30	11.90	93.82	29.11
12-roller Mill 1920	87.20	83.42	3.78	84.55	1.13	68.74	18.46	97.53	38.40
Increase or decr'e.	.....	.....	.79	.....	.27	.....	6.56	3.71	9.29
15-roller Mill 1910	88.89	84.76	4.13	86.20	1.44	73.3	15.59	95.53	39.50
15-roller Mill 1920	88.73	85.81	2.92	86.57	.76	70.58	18.15	97.56	24.53
18-roller Mill 1920	83.14	79.19	3.95	81.15	1.96	64.88	18.26	97.08	39.15
21-roller Mill 1920	90.11	86.67	3.44	88.40	1.73	67.24	22.87	99.05	54.32

N. B.—In 1910 there was one and in 1920 two 15-roller mills. There were no 18 and 21-roller mills in 1910; only one of each in 1920.

All averages are arithmetical.

## HAWAIIAN FACTORIES' ANNUAL SYNOPSIS.

Comparing the purities of the crusher juice against the purity of the syrup, we have the following:

	Crusher Juice Purity	Syrup Purity	Difference
9-roller Mill 1910 .....	88.86	88.44	.42
9-roller Mill 1920 .....	86.98	84.91	2.07
12-roller Mill 1910 .....	90.20	88.61	1.59
12-roller Mill 1920 .....	87.20	84.55	2.65



Why not use the apparent purity of the crusher juice in the S. J. M. formula for calculating the recovery? Allowing a difference of, say, .8 between the purities, it seems reasonable to assume that the rest is lost between the crusher and the evaporator. Probably more at the mill than from the juice scale to the evaporator.

By increasing the purity of the mixed juice 1% there is a calculated increase in recovery of .83% and 1.19% on the polarization in mixed juice. No doubt about it that this is a very serious loss that has been overlooked for years.

COMPARISON OF ACTUAL WEIGHT OF CANE AND CALCULATED WITH  
DIFFERENT NORMAL JUICE FACTORS

(From Paauhau Lab. Report 32, March 8th, 1921.)

Actual weight of cane, 699.85 tons.

Calculated weights:

Factor used .....	95	96	97	98	99	100	101
Tons cane .....	706.35	698.75	691.43	684.25	677.38	670.22	663.12

*From Mr. T. V. Petersen, Chemist at Laupahoehoe Sugar Company:*

The following figures relate to a test on deterioration of so-called sweet water from second presses, which is often used for macerating purposes:

	Brix	Polariza- tion	Purity
Standing half hour .....	2.0	1.4	70.0
Standing one hour .....	2.1	1.3	61.9
Standing one and a half hours .....	2.1	1.2	57.1
Standing two hours .....	2.2	1.2	54.5

*From Mr. W. K. Orth, Superintendent Koloa Sugar Company:*

In answer to your letter of June 17th, in regard to mill equipment, I have this to say for Koloa:

The extraction figures for last season and this season up to date (29 weeks in both cases) are:

	1920	1921
Extraction % Pol. i. c.....	96.69	97.73
Maximum for one week .....	97.08	97.78
Milling loss .....	3.02	2.31
Minimum for one week .....	2.71	1.78

Extraction and milling loss are appreciably better this year, even if we give due credit to the lower grinding rate this year of 29.12 tons cane per hour, against 32.21 last year. Dilution was alike 44.00%.

The improvement is due to several changes in the mill. First, to a new crusher with hydraulics in place of springs, original size as previous.

Then we replaced four rather worn rollers in such manner that the little-

worn back rollers of each mill were placed in front and the new rollers became bagasse rollers, the old front rollers going in reserve. This combination works well as long as the top rollers are the smallest in the set and the bagasse rollers the largest. The juice grooves were deepened to  $1\frac{1}{2}$ " and the rollers set as close as possible. The distance returner bar to back roller was increased from  $\frac{1}{4}$ " to  $\frac{3}{8}$ " and  $\frac{1}{2}$ ".

Another slight improvement worth mentioning is a piece of 00 centrifugal screen put on the mill juice screen frame where the juice spout enters the screen trough. This fine screen retains quite a bit of fine cush-cush that was formerly pressed through the larger openings of the old screen by the fall of the juice onto the screen.

Much of the better recovery here is, I think, only apparent, Howe juice scales furnishing better means of control than the unreliable Automatic it replaced.

The improvement in waste molasses gravity purity is rather slight and, I believe, partly due to the increased pan, crystallizer, and centrifugal capacity on account of the slower grinding. I did record an average of 37.6 so far this year, but have done almost as well, or poorly, before. The averages for the last five years, counting back from 1920 as first year, are: 38.0, 38.7, 38.4, 38.6, 39.2.

I compiled molasses figures of four representative mills, one on each Island, and find the averages for the last six years, beginning with 1915 as first year:

	1915	1916	1917	1918	1919	1920
Gravity purity .....	40.09	40.51	40.76	39.29	37.35	37.72
% Sucrose lost in Mol. % S. i. C.	6.51	7.46	7.06	7.21	6.47	6.67
Purity first expressed juice .....	88.4	88.3	87.9	88.5	88.4	88.5

Not much of an improvement. This year apparently some better results will be shown, again due, in part at least, to the reasons I gave for Koloa, the temporary larger capacities in T. C. H.

Still, in spite of this reasoning, which at that is in particular supported by the good results at Pioneer Mill since their new centrifugals are in operation, I am not yet convinced that additional outlay for equipment and labor to reduce losses in waste molasses might not be spent to more advantage at the clarification stations than at pan floor, crystallizers, and centrifugals. As long, I mean, as cash allowances will be as limited as they threaten to be for the next few years. Of all the many suggestions that come to mind, I like to mention the use of Filter-Cel. I am just now experimenting with it in a small way, with the object to avoid liming, or rather over-liming, the mud juice. The results are very promising, but can unluckily not be brought to anything like conclusive facts when saving and "let George do the experimenting that costs money" is the parole.

N. B.—I notice that there has been so far almost every week a decrease in purity from mixed juice to syrup, or at most a very slight increase, in three mills that I know have the H. C. & S. continuous settlers—in Puunene, Lihue, and

Makee. It would be interesting to find out if there is perhaps an imperfect movement of the juice in some parts of these settlers that gives rise to inversion.

I am sorry, but that is all I have to offer this year.

*Mr. H. S. Walker, superintendent with Pioneer Mill Company, contributes the following:*

In reply to your letter requesting information as to the improvements put in here during the last few years and their effect on extraction and recovery, I submit the following:

#### PIONEER MILL — IMPROVEMENTS SINCE 1912.

1913.

Changed from 9 to 12 r. m.

New steel mill building and electric crane over mill.

1914.

Ramsay scrapers installed.

March 9, 1914—Messchaert grooves put in feed rollers of second, third, and fourth mills.

Sand filters replaced by wire cloth.

1915.

Replaced intermediate bagasse carriers on all mills by Ramsay macerating conveyors.

Messchaert grooved back roller of fourth mill.

Put in one set of 9 knives, 6" apart, 3" from carrier.

1916.

Messchaert grooved remaining front and back rollers.

Williams shredder installed.

Motorized drives of Lillies, unloader, knives, shredder, and centrifugals.

Six 7x20 R. T. boilers (replacement).

One calandria pan of 900 cu. ft., in July.

One settling tank of 1100 cu. ft.

Four mud presses of 800 sq. ft. each.

Six 40" centrifugals.

1917.

One 800 K.W. turbo generator.

1918.

Number of knives increased to 13.

Capacity of calandria pan increased to 1100 cu. ft.

Two 360 h.p. Badenhausen boilers for running the turbine.

Six 700 cu. ft. crystallizers.

Two mud presses of 800 sq. ft. each.

1919.

None.

1920.

Crusher, 34" x 72", with engine.

One three-roller mill, 34" x 72".

Searby shredder, 72".

New cane carrier, 72".

Number of knives increased to 27.

1921.

Standard evaporator, 24,000 sq. ft. h. s., replacing two Lillies of 16,840 sq. ft. h. s.

One settling tank of 1100 cu. ft.

Sixteen 40" centrifugals for low grades.



Replying to your question as to whether increased extraction has been due to skill of operating or to the newly installed machinery, I think that most of the improvement in extraction at Pioneer in the last ten years has resulted directly from additions or improvements to the mill. Our extraction with a 9-roller mill in 1905 was reported as 94.93. Seven years later it was only 94.87. Following the change to a 12-roller mill for the 1913 crop, extraction went up to 96.13. Messchaert grooves, put in gradually during 1914 and 1915, had very little influence on the extraction, as it was only 96.32 in 1915. The effect of the grooves seems to have been to allow about 20% more cane to be ground than formerly without a loss in extraction. The shredder was used during only part of 1916. The combined influence of Messchaert grooves and shredder increased the extraction a little over 1% from 1913 to 1917. During the next two years no changes were made in the mill and there was very little gain in extraction. The change to a 15-roller mill in 1920, with a wider crusher and better shredder, resulted in a gain of 0.67 in extraction at a 9% faster grinding speed. With the same equipment in 1921 extraction fell back 0.27, though the average tons cane per hour was a little more. Nineteen twenty-one was an exceptionally bad year, both for milling and boiling house work, owing to the prolonged grinding season and the considerable amount of dried-up cane ground.

Judging from our total recovery from year to year, it might be argued that we have spent a lot of money and have nothing to show for it. The overall recovery in 1921 was lower than in any year since 1912, in spite of a higher extraction, and it is quite true that we have been getting less "sugar in the bags" of recent years. A calculation of possible recovery by the s. j. m. formula, however, shows that, considering the lower syrup purities, the boiling house work has at least not fallen off in recent years, and it seems reasonable to believe that, given the same cane to start with, the total recovery would have increased in proportion with the increased extraction. I doubt if this can ever be proven by comparing the work of different years, on account of the variation in the cane itself and the lack of absolute accuracy in methods of chemical control. It would be very difficult, if not impossible, for instance, to prove the simple statement that 1001 tons of cane yield more "sugar in the bags" than 1000 tons.

There are three possible arguments that we are getting little or no benefit from the extra four or five per cent extraction we have obtained in the last ten years or so.

(1) It is believed by some that larger "unknown" losses of sucrose take place at the mills and that long trains of mills, heavy crushing, and fine shredding may increase these losses, even though their "extraction," figured from the sucrose left in the bagasse, may be reported higher. The only way such losses at the mills could be caused is by the action of some living organism—oxidation by the atmosphere is out of the question, as sucrose solutions are not affected by atmospheric oxygen. Repeated experiments made at Pioneer last year showed that the deterioration of our mixed juice on standing one hour without any preservative was so small as to be almost within the limit of experimental error, and that the loss of sucrose during a liberal allowance of fifteen minutes to get from

MILL AND BOILING HOUSE DATA — PIONEER MILL COMPANY.

	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
Tons cane per hour .....	42.04	46.08	53.75	55.98	56.47	58.95	57.10	56.29	61.40	62.77
Dilution .....	51.05	35.49	26.54	34.19	42.38	38.47	33.45	36.34	31.96	39.53
Extraction .....	94.87	96.13	96.20	96.32	96.72	97.25	97.22	97.45	98.12	97.85
Recovery % polarization of cane .....	86.56	88.38	89.27	90.32	89.64	89.93	89.18	89.77	89.58	87.34
Composition of "1st mill juice" .....	Cr. & Gr. & I. W.	I. r.	I. r.	Cr. & I. r.	Cr. & Gr. & I. r.	Cr.	Cr.	Cr.	Cr.	Cr.
Purity crusher or 1st mill juice .....	89.46	88.89	88.50	90.09	88.73	90.32	88.93	88.76	88.98	87.01
Syrup .....	88.69	88.96	87.27	87.47	86.41	88.25	86.20	85.85	86.26	84.28
Drop in purity .....	0.77	-0.07	1.23	2.62	2.32	2.07	2.73	2.91	2.72	2.73
Last mill .....	78.20	73.58	73.91	74.16	70.29	72.47	73.02	67.54	65.71	60.91
% recoverable sucrose in last mill juice .....	85%	80%	80%	80%	76%	79%	79%	73%	70%	63%
Recovery % polarization mixed juice .....	91.23	91.94	92.79	93.77	92.68	92.48	91.73	92.12	91.30	89.27
Tons molasses .....	5858	5185	5228	5462	6612	6037	6625	5937	6230	8084
Gravity purity waste molasses .....	45.82	42.32	39.71	37.64	38.43	39.08	38.39	37.5 *	37.91	36.98
Unknown losses .....	1.10	1.30	0.71	0.73	0.52	1.37	0.81	1.37	1.66	1.38
Theoretical yield, 86 j. 97 s. ....	88.55	90.10	91.14	91.90	91.62	91.38	91.63	91.77	91.80	92.11
Java ratio .....	82.6	84.5	84.0	83.2	81.5	82.0	81.3	81.6	81.0	80.6
Quality ratio .....	6.93	7.06	7.31	7.05	7.43	7.07	7.48	7.12	6.96	7.13
Tons cane per ton sugar .....	7.15	6.82	7.16	6.84	7.35	7.06	7.52	7.09	7.03	7.40

\* By dry lead method.

the mills to the heaters could not have averaged more than 0.03% at the most, of the total sucrose in juice.

Mr. J. N. S. Williams, in a contribution to the Committee on Manufacture of Sugar and Utilization of By-products, quoted from the reports of two factories:

Plantation A: Extraction, 89.1%; fiber, 13.3%.

First Mill Juice, 16.6 polarization; 88.3 purity.

Calculated normal juice, 16.1 polarization; 86.5 purity.

Pure sugar in cane, 279.4 pounds per ton.

Plantation B: Extraction, 96.34%; fiber, 13.76%.

First mill juice, 17.50 polarization; 87.55 purity.

Calculated normal juice, 15.55 polarization; 83.05 purity.

Pure sugar in cane, 268.21 pounds per ton.

He concludes that Plantation B, having apparently a better cane than A to start with, judging from the first mill juices, must have destroyed sugar in the milling process because it is charged up with less total sucrose in the cane.

This reasoning would be perfectly logical if all factories at all times ground a cane of absolutely uniform composition, and if the pressure on all "first mills" were so regulated that the composition of the "first mill juice" bore a constant relationship to the per cent sucrose and purity of the cane itself. Unfortunately this is not the case. Analysis of the juice that happens to be expressed by the first of a train of mills may, by the use of a factor derived from past records of the same kind of cane in the same factory, give a fairly close approximation of the total sucrose actually in the cane, but as a means of anything but very rough comparison between factories it is not very reliable. In fact, by a judicious selection of figures almost any argument might be proved from the variation in this

factor  $\frac{\text{Polarization of cane} \times 100}{\text{Polarization 1st mill juice}}$  or so-called "Java Ratio." The ratio for Plantation A was 84.2, while that for B was 76.6. If we found that all factories getting low extraction had high Java ratios, and those getting high extractions had low Java ratios, the deterioration theory might have some weight, but according to the 1920 annual synopsis it is just as easy to prove that sucrose is destroyed by not squeezing the cane hard enough. Union Mill, with an extraction of 90.29, has a Java ratio of only 75.8, while Olowalu has an extraction of 98.06 and a Java ratio of 81.0. Puunene, with an extraction of 98.92, has a Java ratio of 83.1.

The average extraction of all Hawaiian mills in 1920 was 97.45. To see if there was any tendency for mills getting high extraction to have low Java ratios I divided the mills into two groups, those above and those below 97.45 extractions, and averaged them separately:



	Over 97.45	Under 97.45
Number of mills .....	16	25
Extraction .....	98.10	95.50
Java ratio .....	81.62	79.98
First mill juice, polarization ...	17.00	16.24
First mill juice, purity .....	87.97	86.59
Syrup purity .....	85.86	84.05
Drop in purity .....	2.11	2.54
Polarization % cane .....	13.65	12.97

The mills getting the higher extraction *happen* to have a *higher* Java ratio and *less* drop in purity from first mill juice to syrup. To my mind the only thing this proves is the uselessness of trying to gain any information from such comparisons.

Actually of two mills grinding exactly the same cane, the one getting the lower extraction would be charged up with slightly more sucrose in the cane if the calculation were made by the "inferential" method illustrated in our "Methods of Chemical Control." In calculating the purity of the "normal juice," the juice left in the bagasse is assumed to be of the same purity as the last mill juice, whereas it is generally found that each successive portion of juice extracted has a lower purity. The error is not great, and tends to disappear with higher extractions.

2. In order to get the last portions of sugar out of the cane it has to be so thoroughly broken up, macerated, and heavily crushed that a great many more impurities enter the mixed juice than do when a lower extraction is obtained. Undoubtedly at some time before 100% extraction is reached the impurities extracted with the last portion of sucrose will be in such large proportion that this last juice will be worthless to the boiling house even if obtained at no extra expense. Some consider that we may have already reached this limit at around 97.5 extraction. Attempts to prove or disprove this by comparisons of the drop in purity between "First Mill" juice and mixed juice or syrup are of little value on account of the great variation in the composition of the cane itself. This was especially noticeable at Pioneer this year. Our smallest weekly average drop from crusher juice to syrup purity was 1.31, with a last mill juice purity of 61.42 and an extraction of 98.02; the largest drop was 5.50, with a last mill juice purity of 55.96 and an extraction of 97.76.

Another source of error in comparing present work with earlier years is the lack of knowing just what we are comparing. According to our official methods "*First Mill Juice* is that issuing from the crusher and the first mill." Since the advent of the shredder a number of factories are returning maceration in front of the first mill and must perforce get their so-called first mill juice sample from the crusher juice alone, which may be a point higher in purity than the combined crusher and first mill juices.

Still another chance to go wrong in comparisons comes from the introduction of variety canes. Previous to 1915 this plantation had only Lahaina cane. In

1921 only 40% Lahaina cane was ground, the balance being made up of Striped Mexican, D 1135 and H 109.

In my opinion the purity of the last mill juice (from both rolls) is the only even approximate check we have on the gain due to increased extraction. In a 12-roller mill about the last 2% and in a 15-roller mill the last 1% of sucrose extraction is due to the last mill. The percentage of sucrose available in these last increments of extraction can be calculated from the  $sjm$  formula. I think the arbitrary standard suggested by Mr. S. S. Peck several years ago, that the economic limit of extraction was reached when the last mill juice purity dropped to about the purity of our low-grade massecuites, is as good a guide as we now have. This means that about half of the last 1% of sucrose extracted would be available, the balance going into the molasses.

I am inclined to believe, subject to correction, that with four- or five-cent sugar we are just about at the economic limit with 98 extraction, and that another one per cent will hardly pay for the extra expense in fuel oil, broken rollers and boiling-house equipment required to maintain it.

3. According to the  $sjm$  formula, if the last 1% of sucrose is extracted at 55 gravity purity a little over half of it is recoverable when making sugar of 97 purity and waste molasses of 37.5 purity. The  $sjm$  formula, however, while mathematically correct, does not take into account qualitative differences in the impurities which may make it easier or harder to work the molasses down to a given purity, and it may be possible that the impurities brought into the juice with the last few per cent of sucrose are of such a character that the molasses due to the last mill juice cannot be exhausted to 37.5 or even 47.5 gravity purity with the methods now used. This point has been touched on in the past, but has never had the attention it deserved. As an extreme instance of what *might* be happening, suppose our last mill juice impurities were similar to those in beet molasses. Beet factories, working their low grades in about the same way we do, are unable to exhaust their final molasses to much less than 55 gravity purity. It is evident that a last mill juice of the composition of diluted beet molasses, although of 55 purity, would yield us no sucrose at all and would be worse than useless to the boiling-house. The  $sjm$  formula would still hold good, but we would have to substitute 55 for  $m$  as well as for  $j$  in the case of such a last mill juice.

I hope this supposition is not correct, but so far we have little proof one way or the other. If there is anything in Geerligs' glucose-ash ratio theory, last mill juice should be much more difficult to crystallize down to a molasses of our ordinary purity than is the first mill juice, as there is a decided tendency for the glucose-ash ratio to decrease in the last portions of juice extracted. Data on this subject is not very abundant. Geerligs cites a few analyses of juices from different mills which illustrate this tendency, but the extraction is so low they are not of much use to us. Mr. Glick ran one test this year on Crusher, Mixed and Last Mill juice from the same cane:

	Crusher	Mixed	Last Mill
Brix .....	22.95	15.40	1.50
Apparent purity .....	82.05	77.58	69.3
Gravity purity .....	82.57	77.66	66.0
Glucose .....	1.590	1.240	0.1
Ash .....	0.631	0.545	0.087
Glucose-Ash .....	2.521	2.304	1.153

Unfortunately this was deteriorated cane with a very high glucose content to start with, but the tendency to a diminishing glucose-ash ratio is very evident.

Mr. Peck at the 1918 meeting of the H. S. P. A. suggested that it would be of value to carry on experiments under the auspices of the Station to determine whether we are actually getting sugar from the increased juice that we are extracting, intimating that the small increase in total recovery we are getting might be due to improved methods in the boiling-house *in spite of* a higher extraction of impurities and sucrose at the mills, and agreeing with Dr. Norris that the only way to prove it would be to find out by experiment what purity molasses could be gotten from the last extracted juice.

To carry out such an experiment properly would be more than one factory could well undertake, as it would require special apparatus for clarifying and boiling last mill juice separately, also probably a small crystallizer and centrifugal machine. The whole thing could be done for probably less than five thousand dollars. If it should happen that our last mill juices cannot crystallize out sucrose to yield anywhere near as low a purity waste molasses as we think, it might save us hundreds of thousands of dollars to know it, even at this late day.

Until some such experiment has demonstrated the possible recovery from last mill juice, it seems to me that we shall have to reply to the question, "How much of this increased extraction are you getting in the bags?" by saying frankly, "I don't know."

In discussing mill and boiling house improvements we are apt to consider only the question of increased extraction and greater recovery of sugar, neglecting an equally important point, the value of increased capacity. Practically all the additions to our milling equipment, such as Messchaert grooves, shredders, increased number of rolls, have a double advantage. They can be used either to increase extraction at the same grinding speed or to increase capacity without sacrificing extraction. In our own case the gain from being able to grind faster has probably been worth fully as much if not more than that from increased extraction. In 1921, for instance, our average tonnage per hour was nearly 50% greater than in 1912. This speed did not happen to be necessary in 1921 owing to the shortage of field labor, but was of considerable value in lessening the extra fuel consumption which is ordinarily caused by an irregular cane supply. In 1920 the value of being able to grind faster was especially pronounced. The 1920 crop was finished in 161 days grinding, just two months less time than was needed in 1912. By finishing up in June we were able to get nearly all our sugar to market before the big drop in price came.

Two months delay in marketing 5000 tons of sugar would have cost us



probably as much or more money than we have ever spent in all our mill improvements. Another big advantage of reserve capacity was in being able to speed up the crop and get finished while the juice purities were still good. Most of us have realized this year the loss from deteriorated cane during a grinding season unduly prolonged by causes which unfortunately could not be remedied by mill equipment.

#### SUMMARY.

Since 1912 we have expanded from a 9-roller to a 15-roller mill, put in Messchaert grooves, a shredder and a larger crusher, and have increased the boiling house to correspond with the larger mill capacity. The extraction has increased 3 points; the waste molasses purity has dropped from 45.82 to 36.98. In spite of this our overall recovery in 1921 was only 0.78% more than in 1912, and less than in any other year since then. This is explained by the lower syrup purities in recent years. Calculation by the  $sjm$  formula shows that, given the same purity of syrup each year, there would have been a progressive increase in overall recovery. The drop in syrup purity is not due to a greater loss of sucrose by deterioration at the mills, and is due only in part to an increased extraction of impurities. Attempts to calculate the latter by comparisons based on "first mill juice" are unreliable, owing to variations in cane, crushing and sampling. The purity of the last mill juice is a fair indication of the value of increased extraction and, as far as our present knowledge can be relied upon, we are getting out as sugar "in the bags" from fifty to seventy-five per cent of the last two or three per cent of sucrose extracted by the mills. It is barely possible that qualitative differences in the impurities last extracted may make the sucrose accompanying them much less valuable than we now believe. This point can and should be settled by experiment. Increased extraction is not the only advantage gained from mill improvements; capacity and flexibility may be of equal or greater value than extraction.

#### STEAM TRAPS: THEIR USE IN THE BOILING HOUSE.

By G. F. MURRAY, Sugar Boiler, Hamakua Mill Company.

The use of steam traps in the boiling house proper was not advocated by sugar boilers until comparatively recently, the general opinion being that in order to drain heating surfaces properly it was necessary to have steam blowing through to the hot well. In fact it is still common practice in some localities, especially with coil pans, to have the tail pipes fitted with "tell-tale" pipes to show the drainage, and in order to be sure the pan man will usually allow steam to blow through.

Traps in connections with heaters, pre-evaporators, or first bodies of evaporators are not necessary as long as the pressure used does not exceed 5 pounds, as with that pressure it is possible to submerge the outlets of the various drains in the hot well to prevent the loss of steam.

However, it is sometimes necessary, even in the best balanced factories, to use live steam, either as make up or to speed up the process, and if the various apparatus are not properly equipped a serious loss of steam results.

When installing traps, two things should be taken into consideration: First,

the capacity of the trap in gallons per minute; and, second, head room available below heating surface to be drained.

In considering the size of a trap to be used it is good practice to calculate the maximum gallons per minute of condensate the trap will be called upon to handle. For instance, a calandria pan will deliver more condensate the first hour of boiling a strike than any subsequent hour.

It is a good plan to have a trap of at least 10% oversize.

Traps should be set not less than six feet below the lowest part of the heating surface to be drained; in fact, the greater the fall between the heating surface and trap the less trouble will be encountered in its operation.

The traps should discharge into a pipe large enough to handle the water without any back pressure on the trap.

A sediment catcher should be installed on the inlet pipe to trap, and should be bled at intervals to prevent any particles of scale, etc., from finding their way into the valve mechanism and interfering with the proper functioning of the trap.

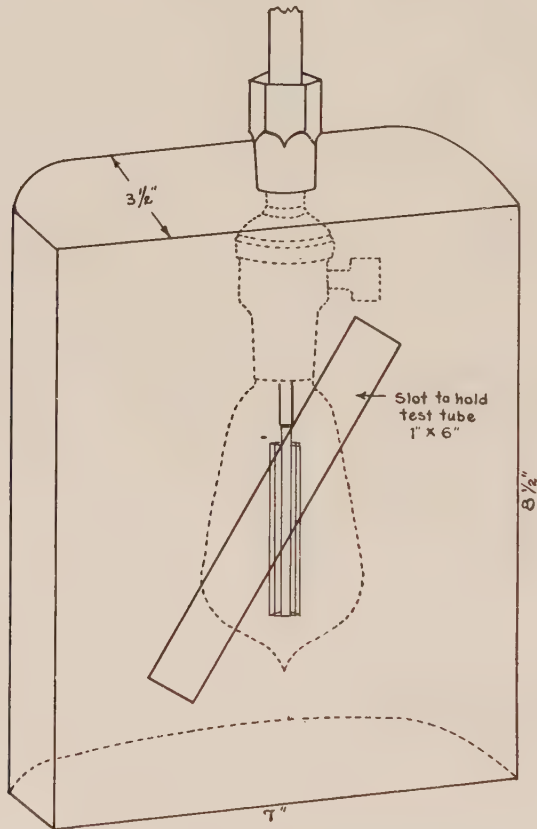
In some factories coil pans are fitted with a trap for each coil, but one trap of ample size will usually suffice if the tail pipes are fitted with proper check valves and discharge to a manifold before entering the trap. In connection with coil pans it has been found necessary to bleed the sediment trap once during each strike to remove any incondensable gases that may accumulate.

The type of trap to be selected is largely a matter of opinion. The writer prefers a trap with all working parts exposed, as it is possible to tell at a glance whether the trap is functioning properly or not.

In conclusion, the advantages of steam traps in the boiling house are manifold. Their proper use means faster boiling, better drainage of heating surfaces, more condensate, less worry for the sugar boiler, less steam consumption, and, through the latter, more trash in the fire room.

## Entrainment Indicator.

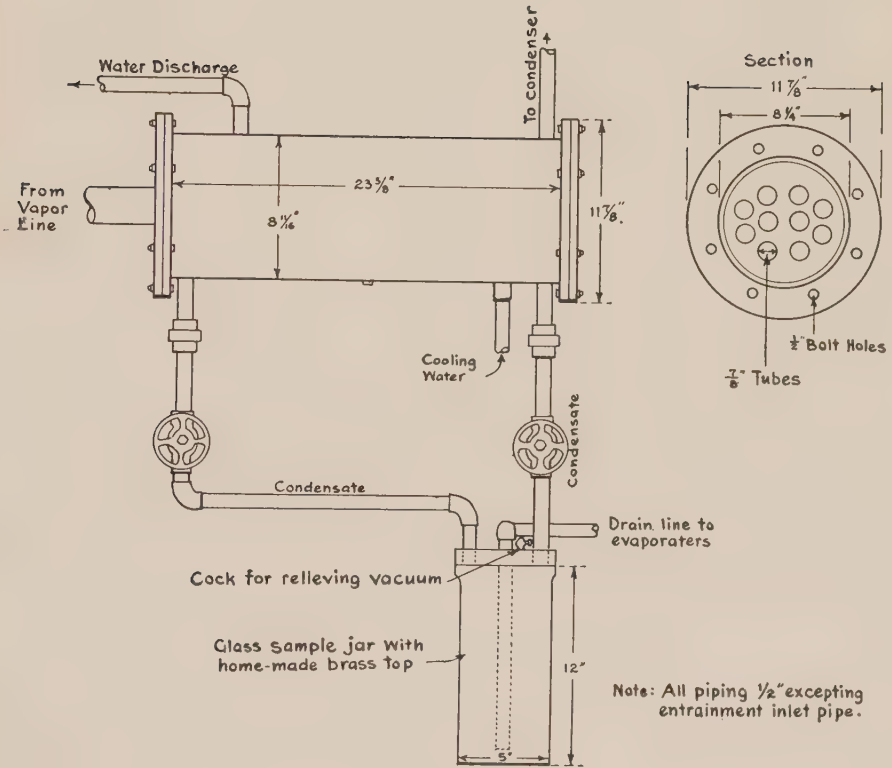
This is a device for testing the rate of settling in mixed juice after it has left the heaters, which consists of a box made of sheet brass  $1/16''$  in thickness, with a slot approximately  $6''$  long by  $1''$  wide, at an angle of  $45^\circ$ , and containing an electric globe.



A test tube,  $6''$  long by  $1''$  diameter, is filled with juice and placed in the slot and the action observed. The object of the slot at that angle is so that the suspended particles which have a certain amount of air adhering to them can rise to the top, where it is released, the particles flowing down the side to the bottom without obstructing the other particles.

RAYMOND ELLIOTT.





Planned and installed by  
Mr. Murray, Chief Engineer  
at Paauhau.

Paauhau Plantation Co.  
Entrainment Indicator  
June 8, 1921.

## SUGAR PRICES FOR THE MONTH

Ended November 15, 1921.

		96° Centrifugals		Beets	
		Per Lb.	Per Ton.	Per Lb.	Per Ton.
	(Oct. 16, 1921).....	4.11c	\$ 82.20		
	“ 18 .....	4.055	81.10	No quotation.	
	“ 19 .....	4.00	80.00		
[11]	“ 21 .....	4.155	83.10		
[12]	“ 24 .....	4.00	80.00		
[13]	“ 25 .....	4.11	82.20		
[4]	“ 26 .....	4.08625	81.725		
	“ 27 .....	4.11	82.20		
[5]	Nov. 2 .....	4.0626	81.25		
	“ 4 .....	4.11	82.20		

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[1] Cubas 4.11. Venezuelas 4.20. Export.

[2] Philippines.

[3] Cubas.

[4] Philippine and Porto Rico 4.0625. Cubas 4.11.

[5] Porto Ricos.

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